Luncheon Panel - 25/oct/2012

The “Hemodynamic Approach” to improve CRT Response

Contractility-driven CRT: principles & methods

Antonello VADO, MD

Elettrofisiologia – S.C. Cardiologia

Ospedale S. Croce e Carle - **CUNEO**

Setting the scene: the "State of the Art"

…[…]… AVD optimization in sequential & BiV pacing, although widely recommended, is often poorly performed in clinical practice as an improper setting can reduce the success of the pacing therapy.

Despite the several methods proposed, **the AVD is frequently programmed in an empirical way or left to a predefined value** (usually the manufacturer's setting), **without considering the different variables** involved in this context:

- ***intra- and inter-individual variability*** of the EM events;
- peculiarities of the ***several CMP***;
- spontaneous ***inter-atrial and AV conduction*** characteristics;
- ***medical*** therapy;
- pacing ***mode***.

…[…]…

Europace (2012) **14**, 929–938
doi:10.1093/eupace/eur425

REVIEW

Optimization of the atrioventricular delay in sequential and biventricular pacing: physiological bases, critical review, and new purposes

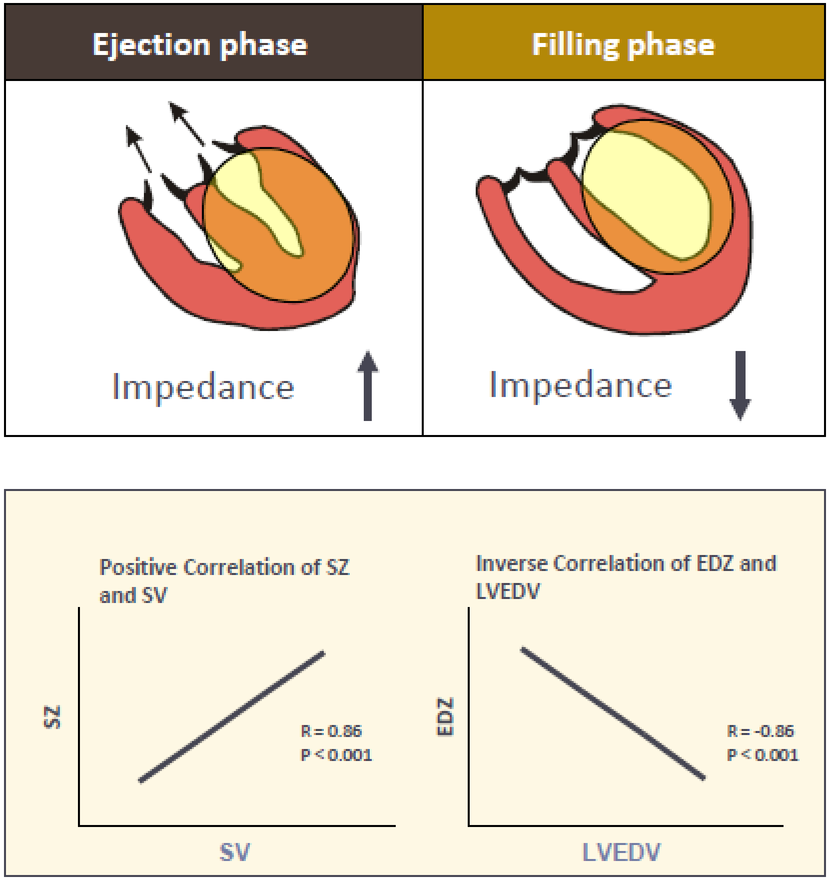
Lanfranco Antonini*, Antonio Auriti, Vincenzo Pasceri, Antonella Meo, Christian Pristipino, Antonio Varveri, Salvatore Greco, and Massimo Santini

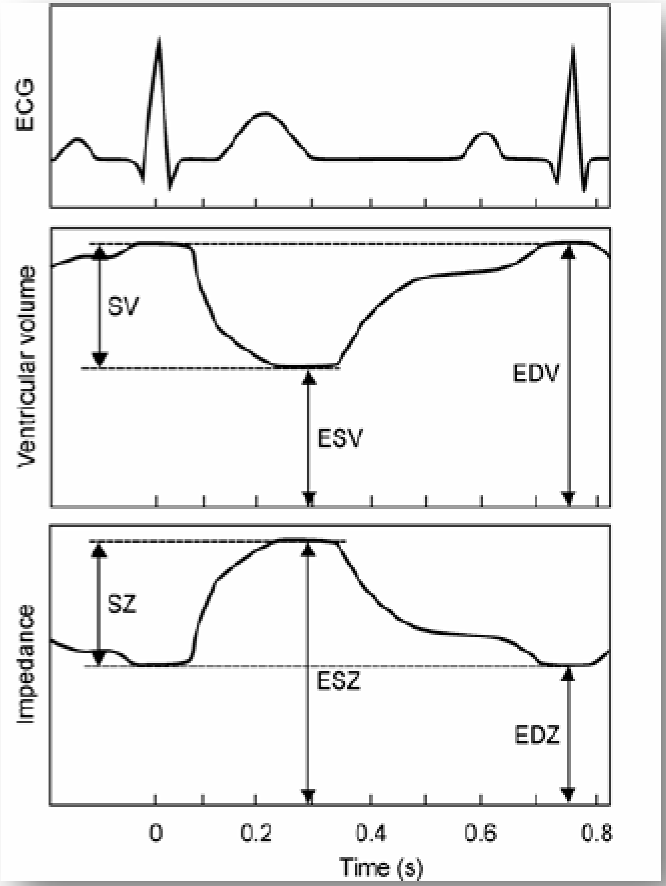
Antonini L & al. Europace 2012 July (background & critical review)

Contractility-driven CRT

- PEA
- LV impedance

Contractility-driven CRT: LV impedance





1950: the modern science of "cardiac auscultation"

AUSCULTATION OF THE HEART*

BY

SAMUEL A. LEVINE†

From the Medical Clinic of the Peter Bent Brigham Hospital and the Department of Medicine of the Harvard Medical School, Boston, Massachusetts

Received July 21, 1948

Levine SA, Br Heart J 1948

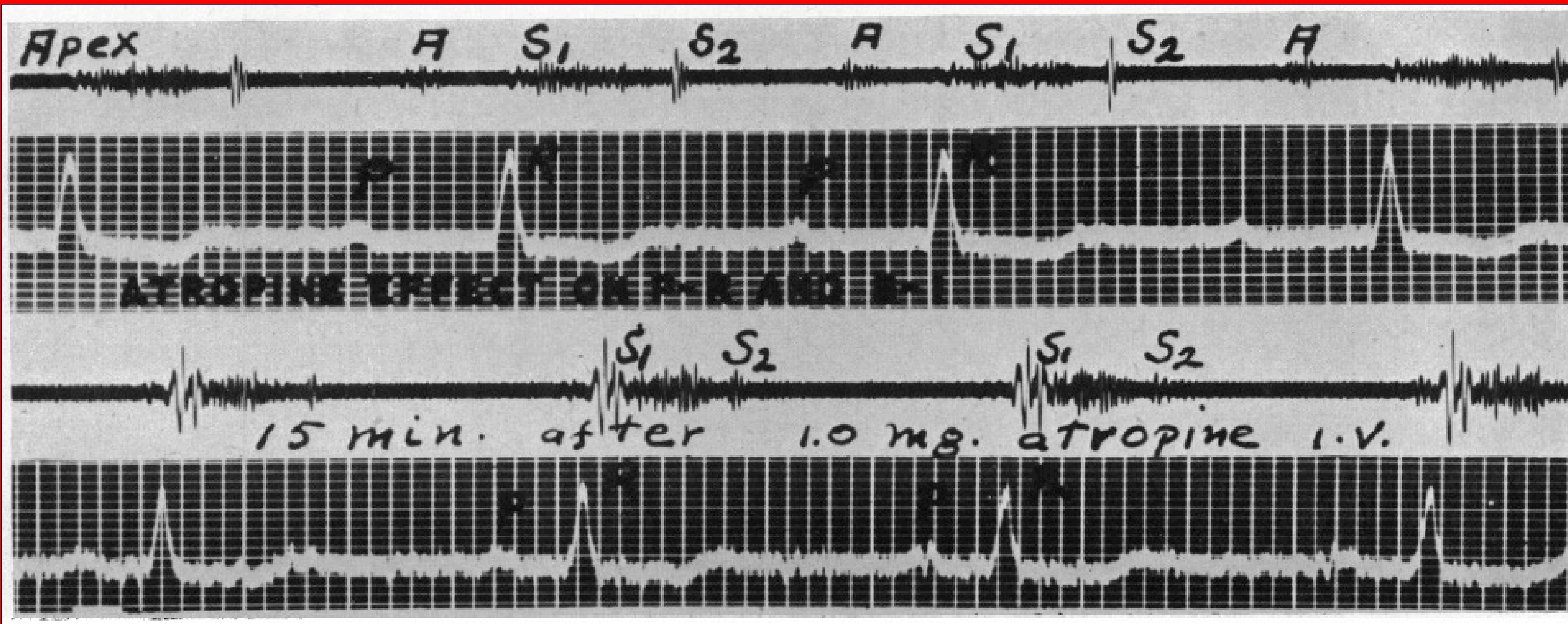


FIG. 5.—Upper tracing shows faint first sound (S–1) with long P–R interval (0·28 sec.). Lower tracing shows loud first sounds (S–1) 15 minutes after 1 mg. atropine i.v. when P–R interval was normal (0·18 sec.). Auricular sounds (A) were detected in upper tracing.

1970: new tools to investigate "cardiac hemodynamics"

Fishleder BL (Inst. Nac. Cardiol. Mexico, 1975)
Piccolo E (Piccin Ed., Padova-It, 1976)
"Cardiovascular Exploration &
Clinical Phono-Mechano-Cardiography"

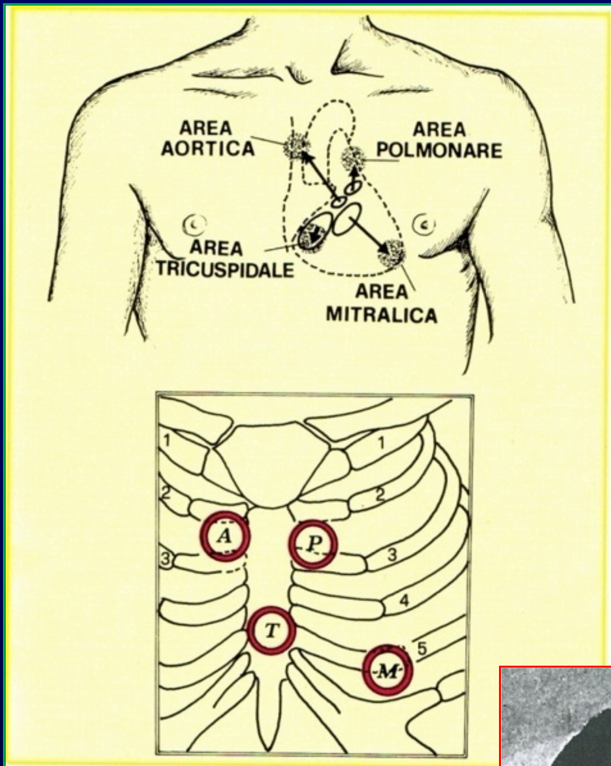


Fig. 1-26. Focolai di ascoltazione « classici » e loro relazione con la proiezione delle valvole. *F.A.* focoaio aortico. *F.P.* focolaio polmonare. *F.M.* focolaio mitralico. *F.T.* focolaio tricuspidale. *V.A.* valvola aortica. *V.P.* valvola polmonare. *V.T.* valvola tricuspidale. *V.M.* valvola mitralica.

...re una caramella in bocca che un catetere in ...ena »[30]. Per la registrazione fonocardiografica ...equentemente addormentiamo i lattanti o i bam-...

1. Focolaio mitralico, che si localizza abitualmente a livello dell'apice (4° o 5° spazio intercostale sinistro e linea emiclaveare) o leggermente all'interno di questo. Benché non corrisponda alla proiezione reale sul precordio della valvola mitralica, è senza dubbio il punto dal quale meglio si ascoltano i fenomeni acustici derivanti da detta valvola.

2. Focolaio tricuspidale alla base dell'appendice xifoide o vicino al margine sinistro della parte più bassa dello sterno.

3. Focolaio polmonare, nel secondo spazio intercostale sinistro, vicino al margine sternale.

4. Focolaio aortico nel secondo spazio intercostale destro, vicino al margine sternale.

Inoltre sono stati denominati:

5. « Focolaio mesocardico » o « accessorio aortico » nel terzo spazio intercostale sinistro, vicino al margine sternale.

6. « Punto di Erb » a metà distanza tra il « focolaio accessorio aortico » e l'apice. Tale focolaio è anche detto « endoapicale ».

Benché questi focolai e le localizzazioni descritte siano di grande importanza dal punto di vista didattico e per la loro diffusione nella nomenclatura cardiologica, non si deve dimenticare che nella pratica la loro topografia può essere molto

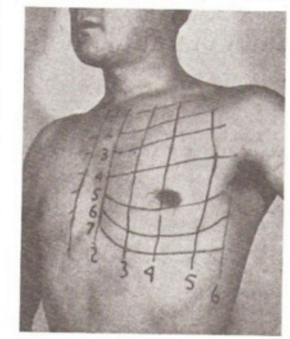
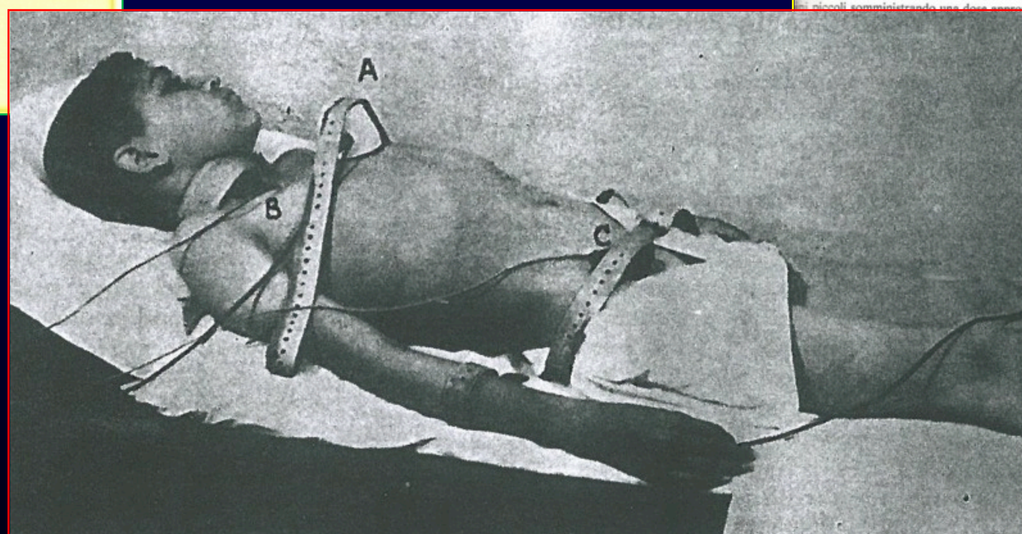


Fig. 1-27. Nomenclatura precordiale quadrettata. Le linee verticali da 1 a 6 intersecano i punti da C_1 a C_6 dell'elettrocardiogramma. Le linee orizzontali seguono gli spazi intercostali (vedi il testo).



Phonocardiogram, carotid & femoral pulse, ECG

G Ital Cardiol (5(5):724-36, 1975.

Studio della ii derivata del polso carotideo (carotidogramma di accelerazione) nelle malattie cardiovascolari. Note introduttive.

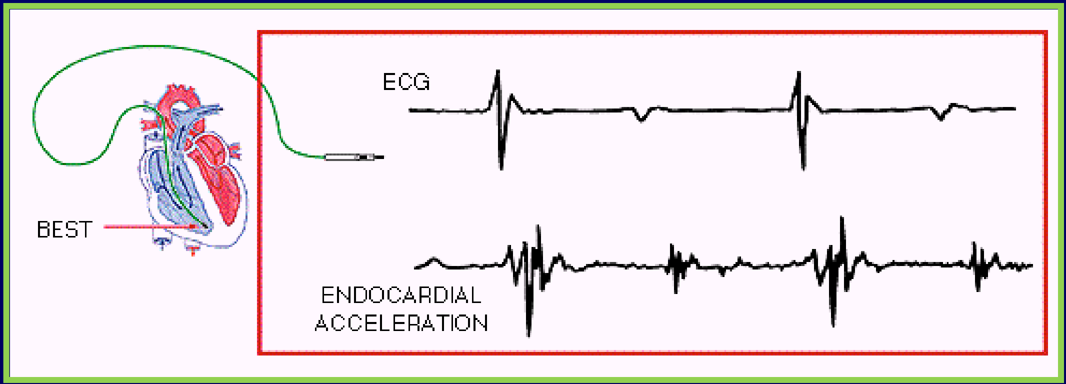
Título alternativo: [**Study of the carotid pulse with lead II (acceleration carotidogram) in cardiovascular diseases. Introductory note**]

Resumen: **The relationship between heart dynamic and the carotid pulse has been studied by using the second derivative as a function of the time of the carotid pulse. This method permits a detailed analysis of the systolic phase of the carotid pulse: in protosystole a positive wave preceeds a negative wave and in telesystole a negative wave preceeds a positive wave. The morphology of the acceleration carotid pulse (CDA Carotidogramma Di Accelerazione), represented by a series of formulas which relate between themselves the protosystolic and the telesystolic waves, is a characteristic as well as statistically significant in each class of the cardiovascular disease in which we examined aortic insufficiency and stenosis, mitral insufficiency and stenosis, aortic angiosclerosis and hypokinetic myocardiopathy. We propose the use of the CDA for a precise analysis of the process of contraction and relaxation of the left ventricle. Since the acceleration with which a phenomenon evolves is the expression of the strength that has generated it, the CDA is particularly effective for the study myocardial dynamic.**

Autor/es: **Grassi T** - **Lavezzaro G** - **Bevilacqua R**

The inspiring concept:

Endocardial Acceleration mirrors myocardial vibrations during isovolumic phases



Peak of Endocardial Acceleration (PEA):
technology derived from a collaboration between SORIN Biomedica (Saluggia-VC, Italy) & the Biomedical Technology Dptm. of the University of Bologna

- **1991**: epi- & endocardial sensors (animal mode studies)
- **1993**: first tests on humans
- **1995-6**: clinical evaluation & CE mark
- **1997**: int'l launch of BEST-LIVING system

BEST - LIVING System

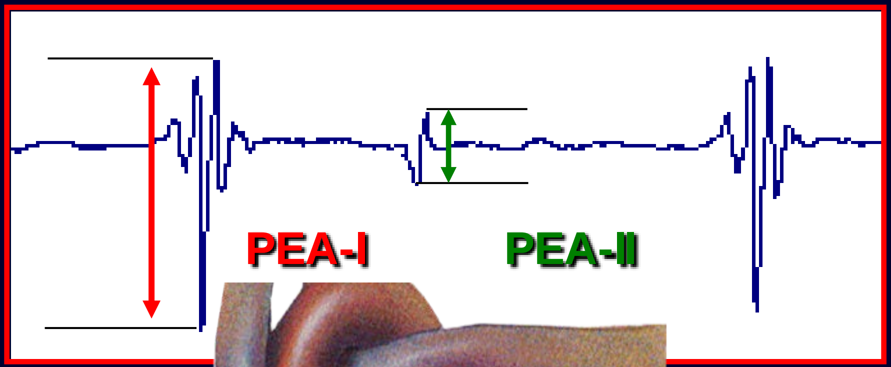
BEST (*B*IOMECHANICAL *E*NDOCARDIAL *S*ORIN *T*RANSDUCER) was the sensor

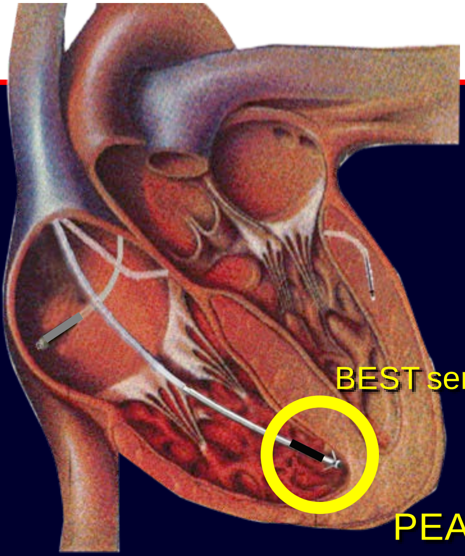
PEA (*P*EAK *E*NDOCARDIAL *A*CCELERATION)

was the signal measured by the BEST sensor (u.m. **g** – gravity acceleration)

LIVING pacemakers family able to use the PEA signal

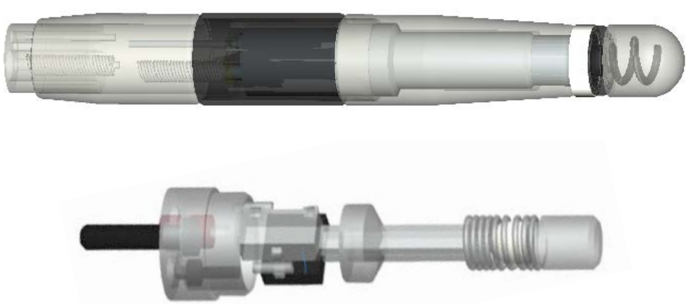
PEA signal (peak of endocardial acceleration) & Heart Sounds





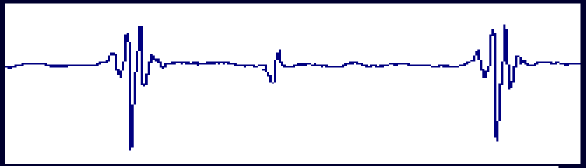
BEST sensor (Sorin Biomedica)

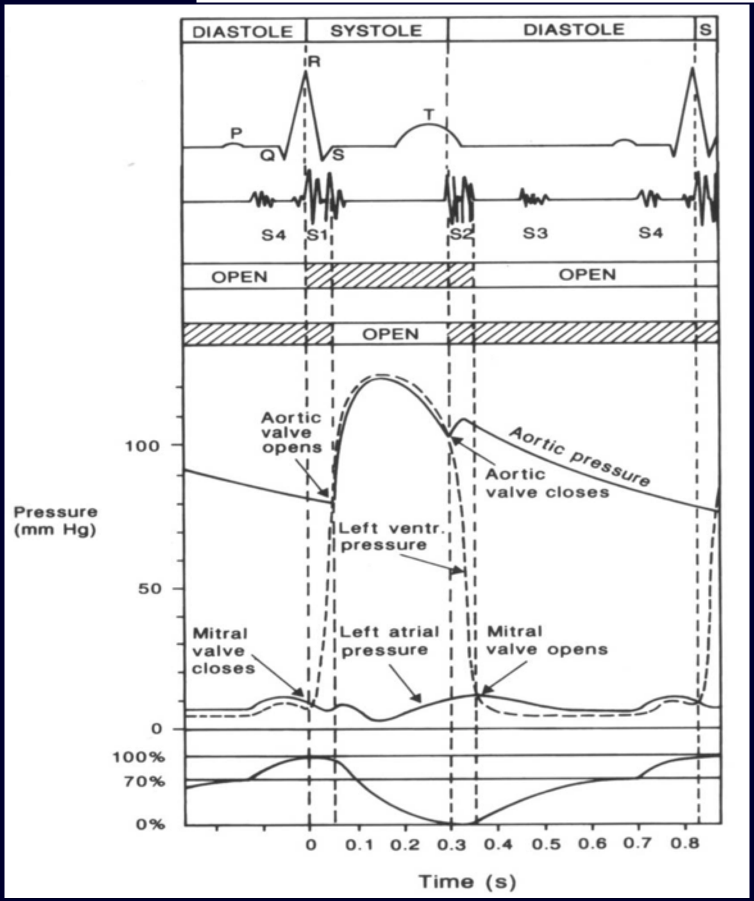
PEA: 1995-2007 (RV tip)



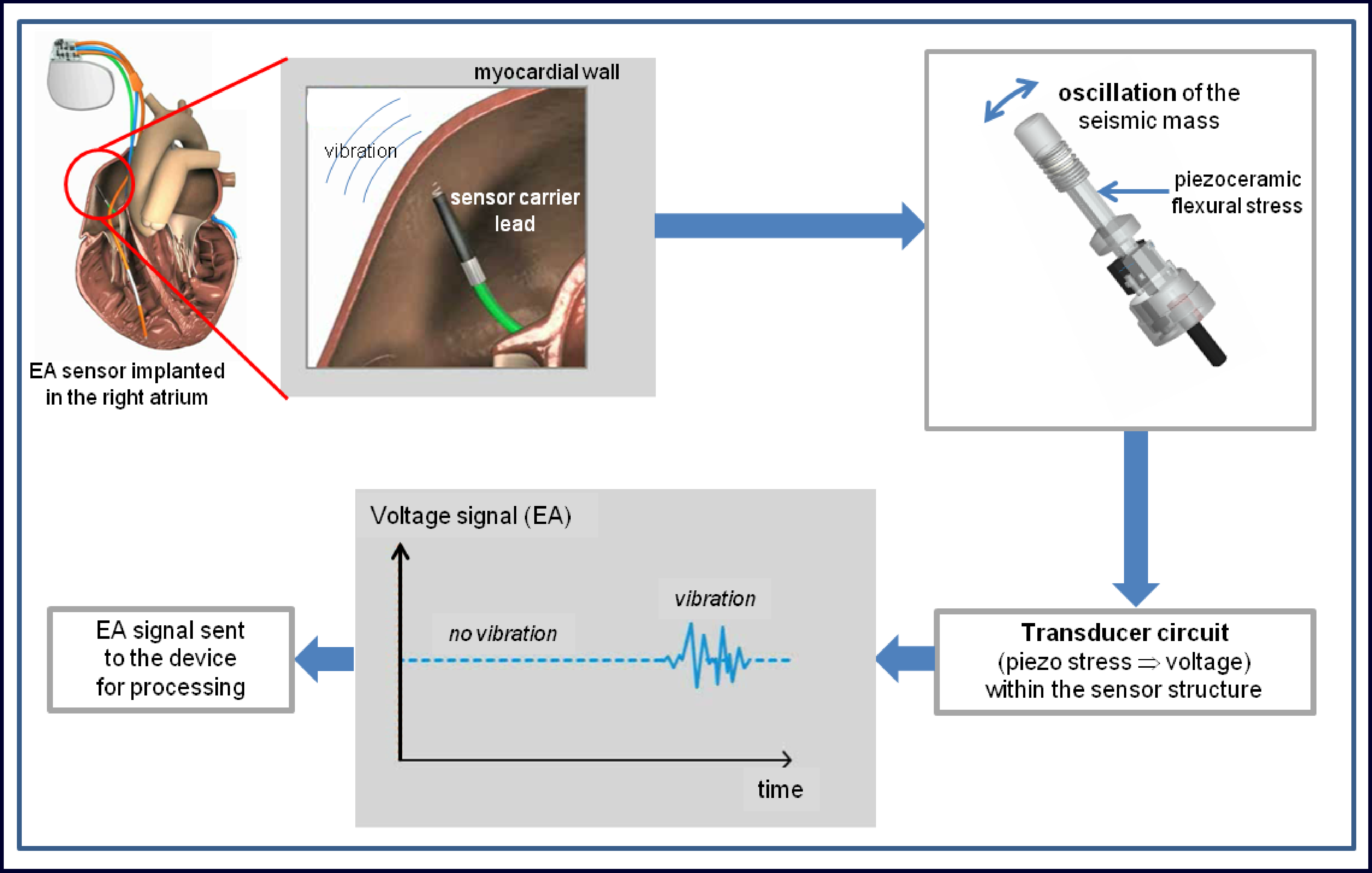
micromass + spring oscillating due to **mechanical vibrations** of the myocardial wall

Endocardial Acceleration Signal

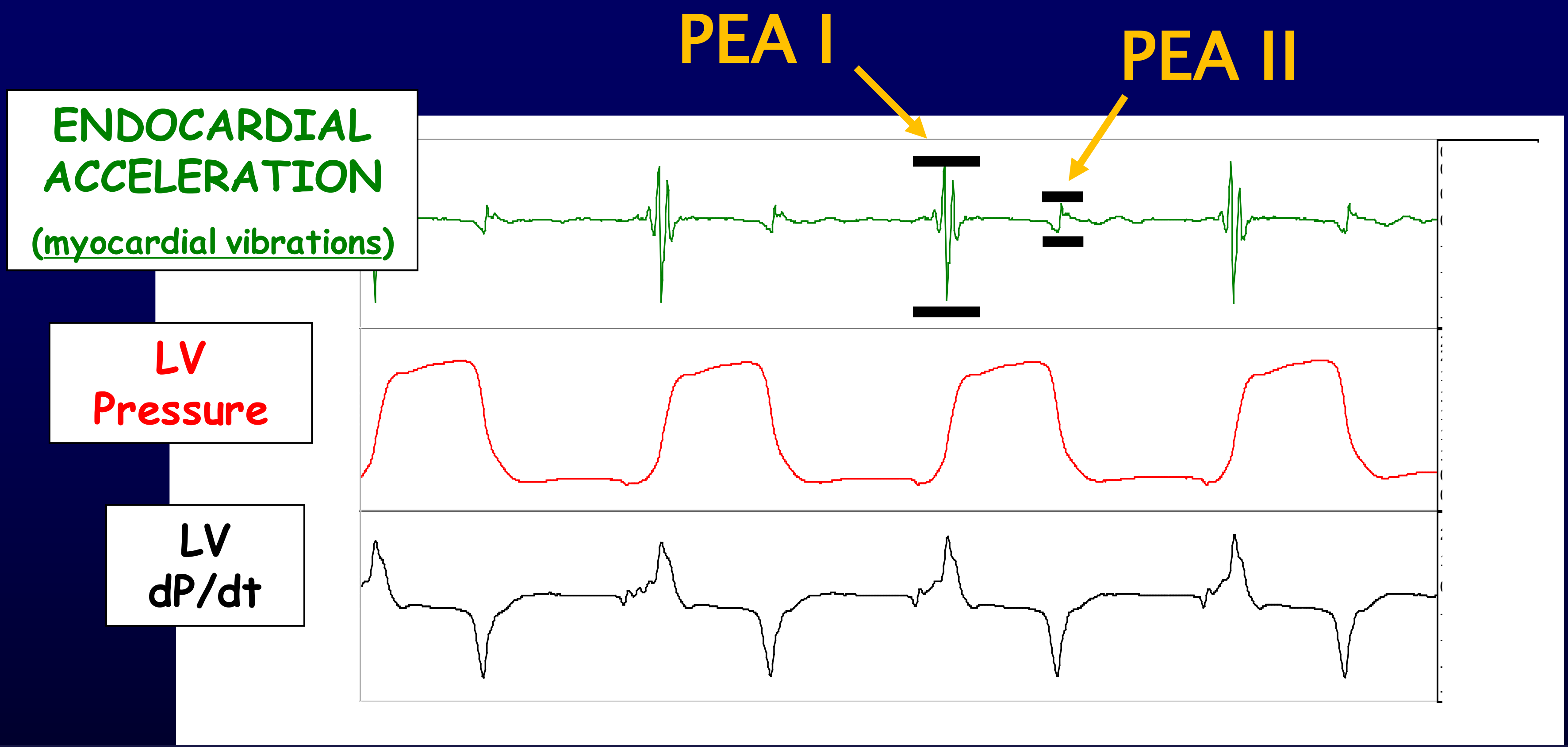




Vibrations (corresponding to the Heart Sounds) are detected independently upon the position of the sensor



PEA signal (BEST sensor in RV tip): Peak of Endocardial Acceleration (g)

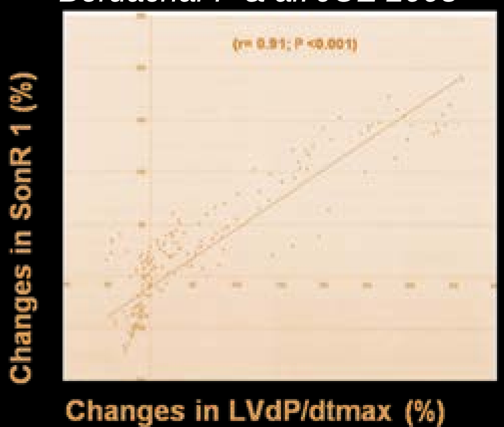


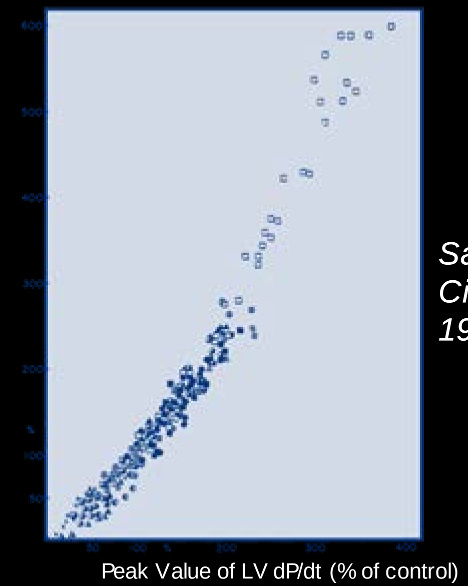
- The BEST sensor detects VIBRATIONS in a specific frequency band:
  - 10Hz ⇒ 70Hz (non-audible components)
  - Cardiac WALLS contractions (macro-movements) have lower frequency (< 5Hz or 300bpm) → they are NOT detected by the sensor
  - EXTERNAL sounds filtered by the ribcage → NO impact on detected signals

Contractility (LVdP/dt) ⇔ Heart Sounds ⇔ SonR

Acute LVdP/dt max correlates with S1

Bordachar P & al. JCE 2008





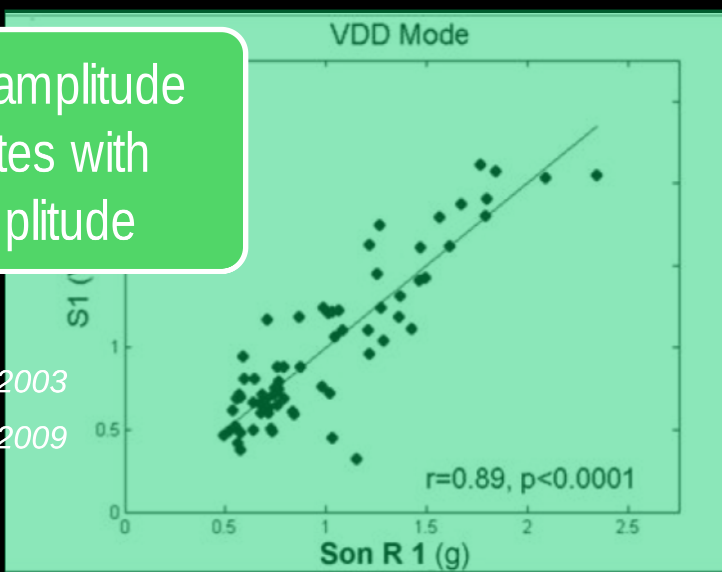
Sakamoto & al. Circ Res 1965;16:45-7

SonR-1 correlates with LV dP/dt max

SonR-1 amplitude correlates with S1 amplitude

Dupuis M & al. PACE 2003

Tassin A & al. PACE 2009

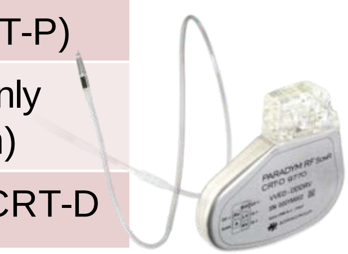


History of endocardial acceleration: from PEA signal to SonR technology

Very rich background about meaning & usefulness of the **endocardial acceleration**:

- "BEST" sensor & "PEA" signal validation (1992-1997)
- signal characteristics (sites, amplitudes, variability) (1995-2000)
- correlation with LVdP/dt under different hemod. conditions (1996-2008)
- AVD optimization in AVB pts (1999-2003)
- **CRT device optimization** (2004-2011)
- pacing site optimization (2010-xxxx)
- HF monitoring (2010-xxxx)

Year	Lead	Fixation	Introducer	Chamber	Device
1995	BEST	Tined	13 Fr	RV	Living DR (PM)
2000-2004	Minibest BestAct	Tined/Screw	11 Fr	RV	NewLiving DR (PM, 2002); Living CHF CRT-P (2004)
2005-2007	Microbest	Tined/Screw	9 Fr	RV	NewLiving DR NewLiving CHF (CRT-P)
2008-2010	SonRfix	Screw	9 Fr	RA	Investigat. Device Only (NewLiving/Paradym)
2011	SonRtip	Screw	9 Fr	RA	Paradym RF SonR CRT-D



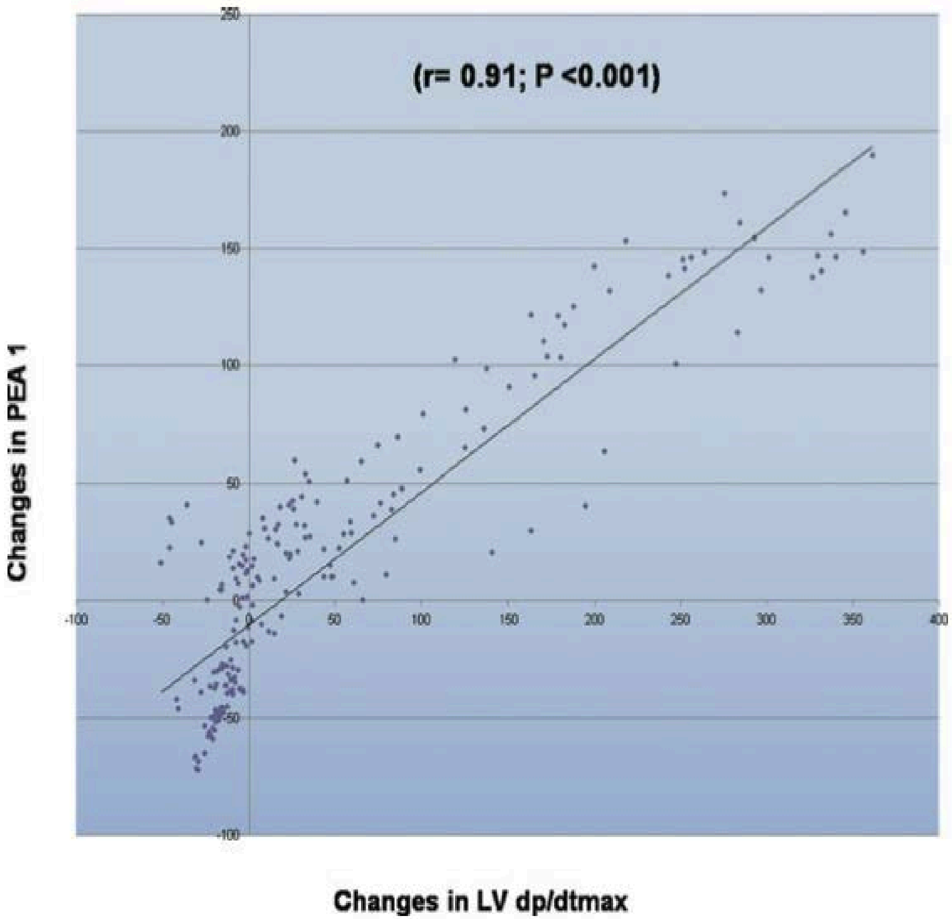
SonR sensor in the right atrium

Contributions of a Hemodynamic Sensor Embedded in an Atrial Lead in a Porcine Model

PIERRE BORDACHAR, M.D.,*,† STEPHANE GARRIGUE, M.D.,‡ PHILIPPE RITTER, M.D.,*,† SYLVAIN PLOUX, M.D.,*,† LOUIS LABROUSSE, M.D.,*,† CYRIL CASSET,§ MICHEL HAISSAGUERRE, M.D.,*,† and PIERRE DOS SANTOS, M.D., PH.D.*,†

From the *Bordeaux University 2, Bordeaux; †University Hospital of Bordeaux, Bordeaux; ‡Clinique Saint-Augustin, Bordeaux; and §Sorin Biomedica, France

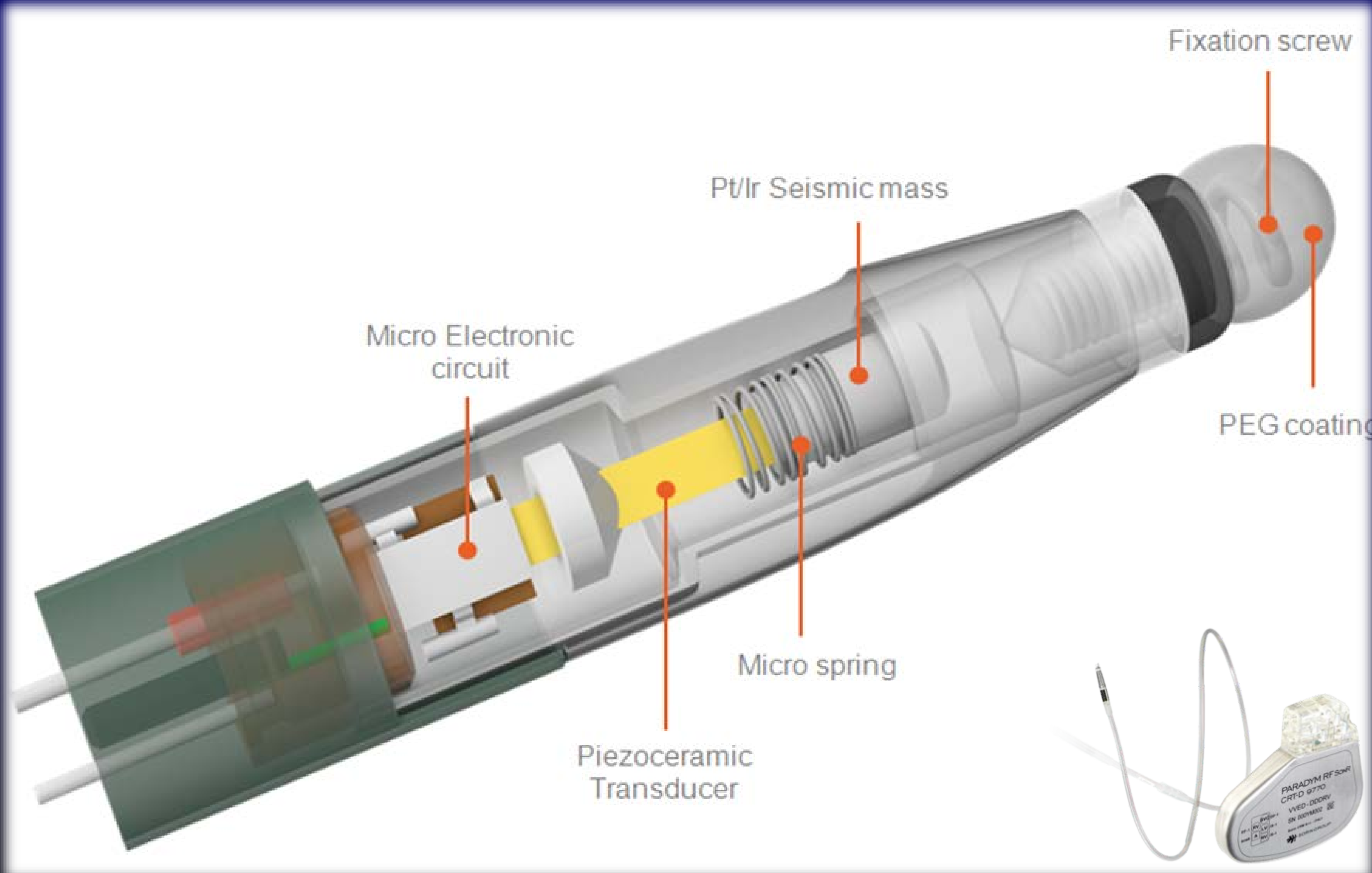
Methods: We placed a PEA sensor embedded at the tip of a right atrial lead in 9 pigs. A 7F Millar catheter tip micromanometer was introduced into the left ventricular (LV) cavity to measure dP/dt_{max}. Myocardial contractility was increased by infusion of dobutamine and depressed by the infusion of esmolol.



Confirmed the possibility to use the SonR sensor in the RA to evaluate the ventricular electromechanical activation (correlates with LVdP/dt)

Bordachar P & al. JCE 2011

SonRtip RA lead (Y-2011)

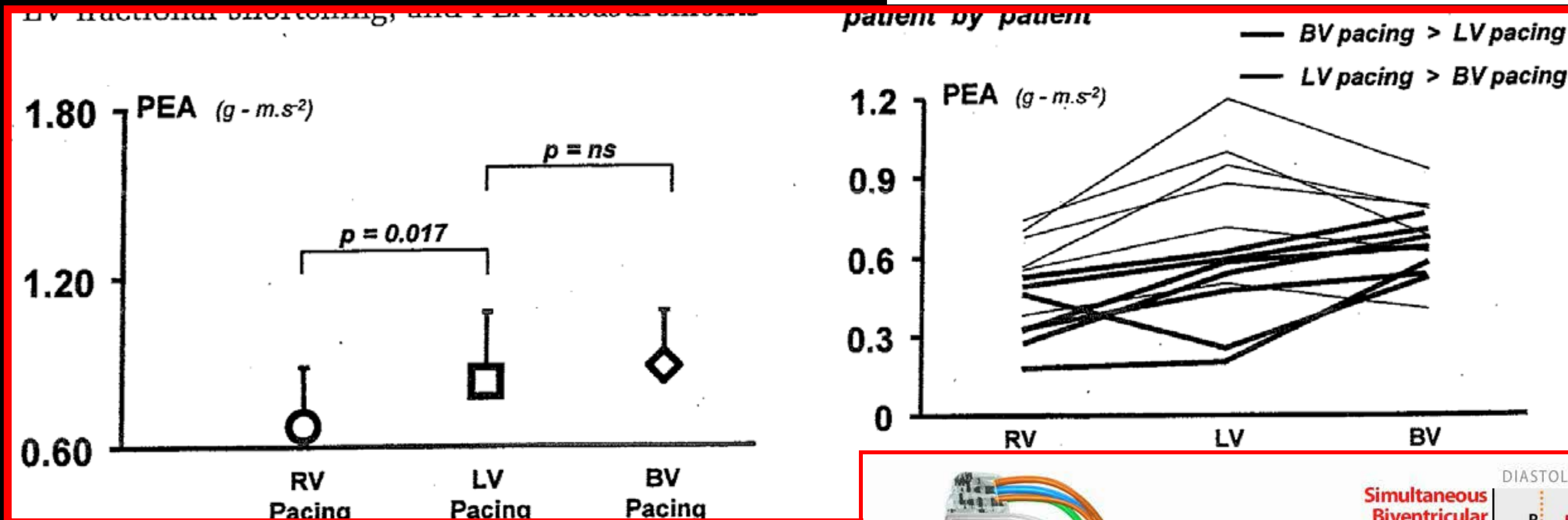


Impact of V-synchrony on SonR signal

Hemodynamic Assessment of Right, Left, and Biventricular Pacing by Peak Endocardial Acceleration and Echocardiography in Patients with End-Stage Heart Failure

PIERRE BORDACHAR, STEPHANE GARRIGUE, SYLVAIN REUTER, MELEZE HOCINI, ADONIS KOBEISSI,* GUIDO GAGGINI,* PIERRE JAÏS, MICHEL HAÏSSAGUERRE, and JACQUES CLEMENTY

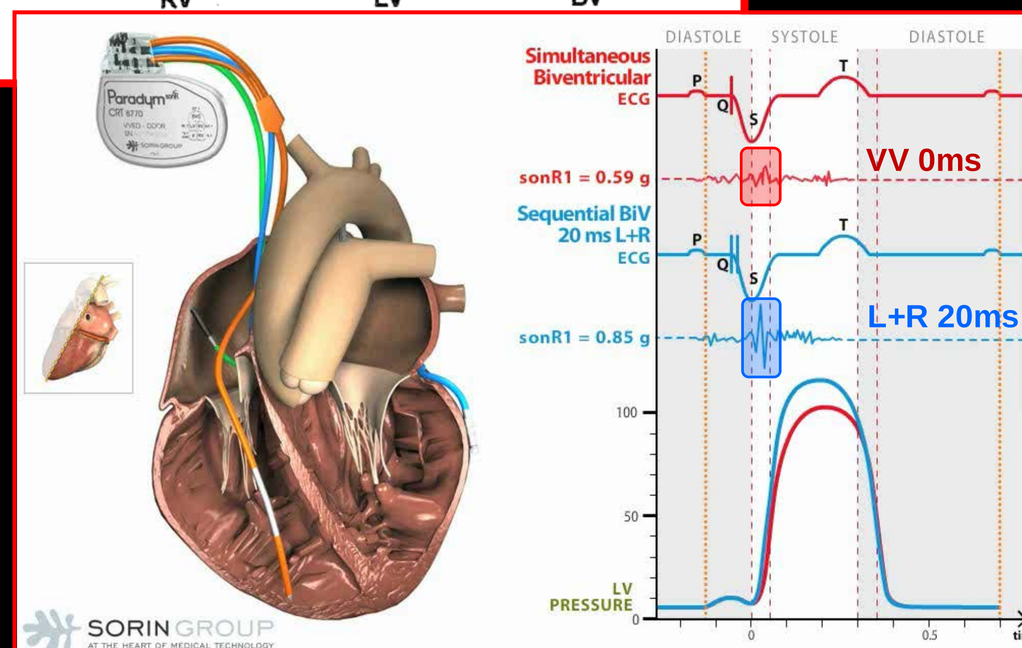
Bordachar P & al. PACE 2000



V pacing configuration, VVD & SonR signal:

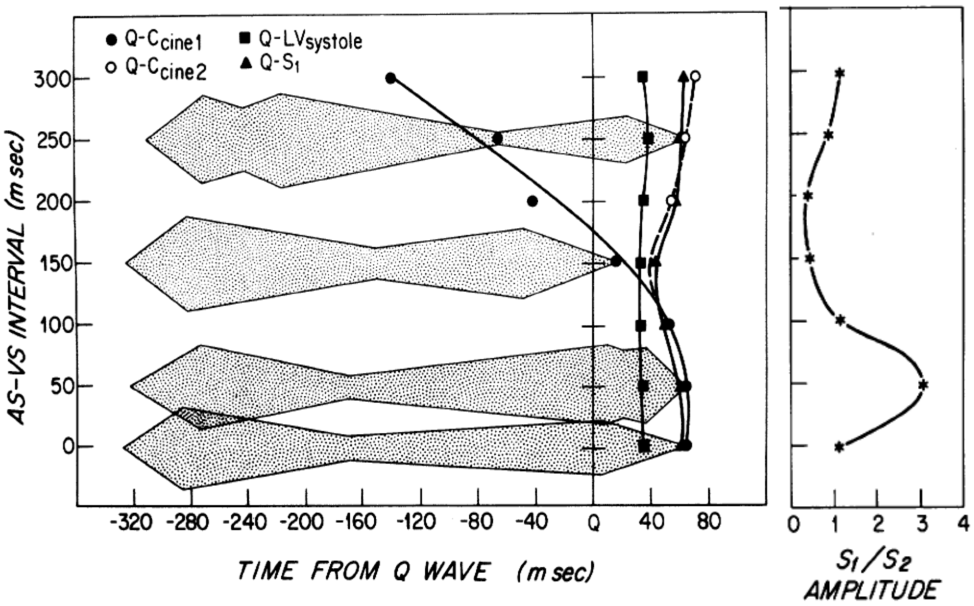
SonR-I amplitude is very sensitive to variations of:
- pacing configuration
- VVD value

The PEA sensor is a promising tool for long-term hemodynamic monitoring and serial evaluation of the effects of multisite ventricular pacing in heart failure patients



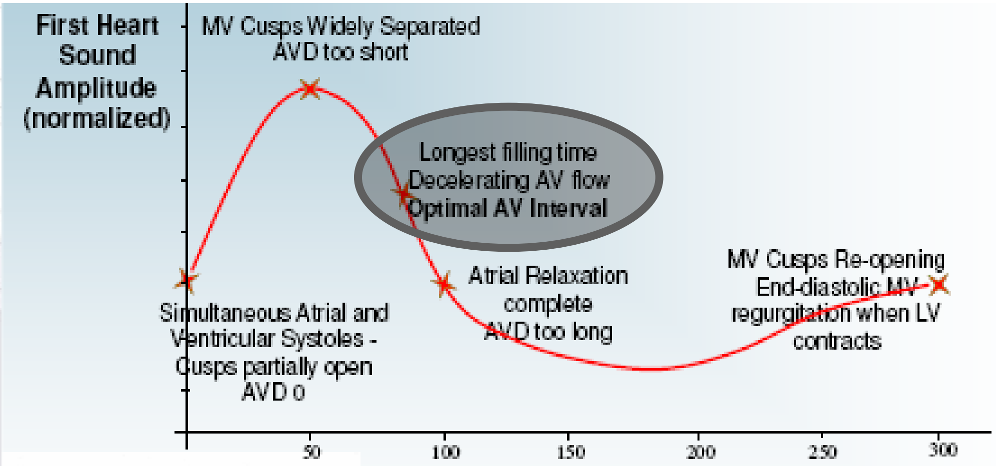
Wexler LF & al, Circulation 1982

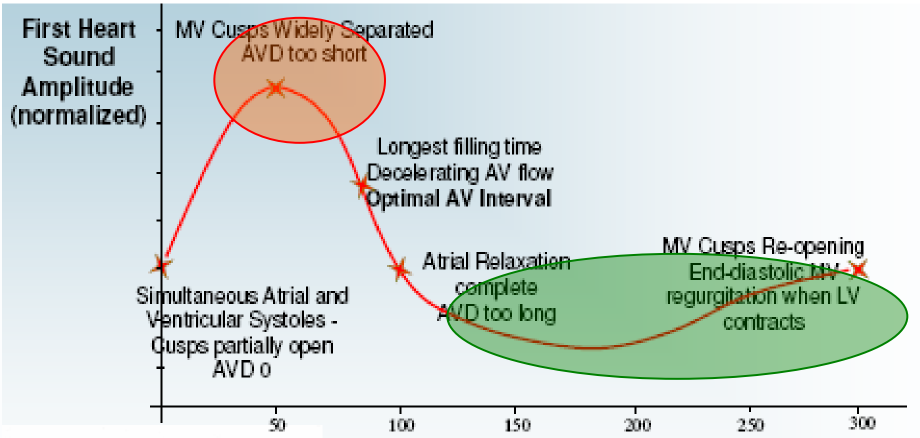
Impact of AV-synchrony on SonR signal



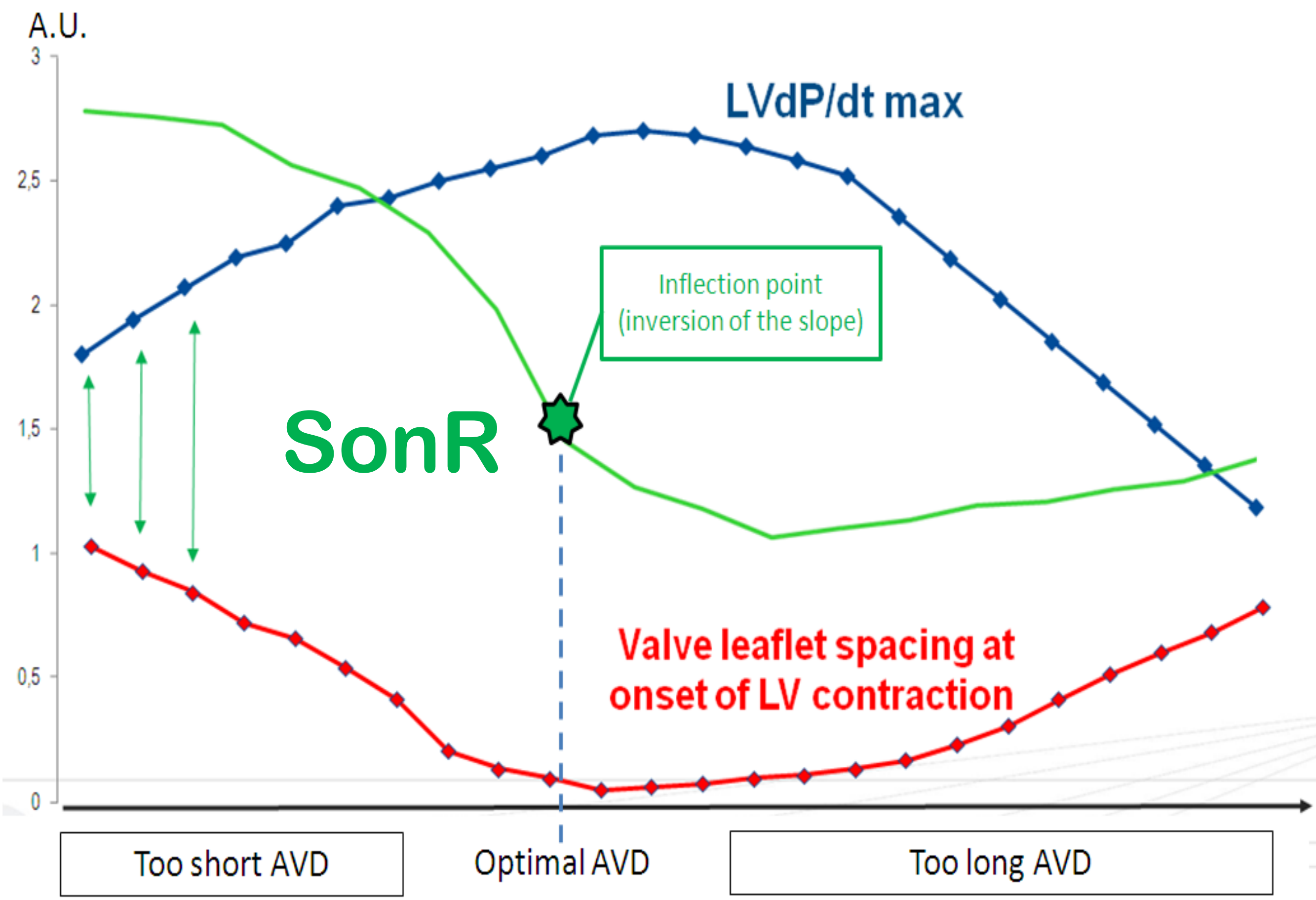
AVD value, first HS, SonR signal

AVD modulation & first HS



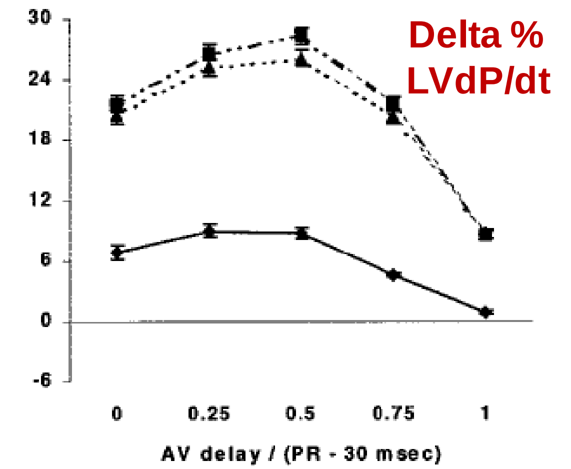


AV-synchrony & SonR signal



Effect of Pacing Chamber and Atrioventricular Delay on Acute Systolic Function of Paced Patients With Congestive Heart Failure

uricchio, MD, PhD; Christoph Stellbrink, MD; Michael Block, MD; Stefan Sack, MD;
Jürgen Vogt, MD; Patricia Bakker, MD; Helmut Klein, MD;
Pacing Therapies for Congestive Heart Failure Study Group; Andrew Kramer, PhD;
)ing, PhD; Rodney Salo; Bruce Tockman; Thierry Pochet, PhD; Julio Spinelli, PhD;
for the Guidant Congestive Heart Failure Research Group



Auricchio A & al. Circulation 1999

Hemodynamic CRT optimization: how ?

Several constraints to develop an algorithm:

- **VVD** optimization (at least @ REST)
- **AVD** values optimization:
  - at rest & under effort
  - in atrial sensing & atrial pacing conditions
- integrates electrical information (PR interval, HR, PAC/PVCs, A-Fib, etc.) together with **hemodynamic** information (SonR)
- **periodically** iterates the whole procedure (**automatically**)

Principles of hemodynamic optimization with the SonR sensor

SonR CRT optimization algorithm

(weekly iteration to adjust AVD & VVD values)

- Optimization of **VVD at rest** *(atrium sensed OR paced)*

  carried-out on Monday h 00:00

- Optimization of **AVD at rest**:

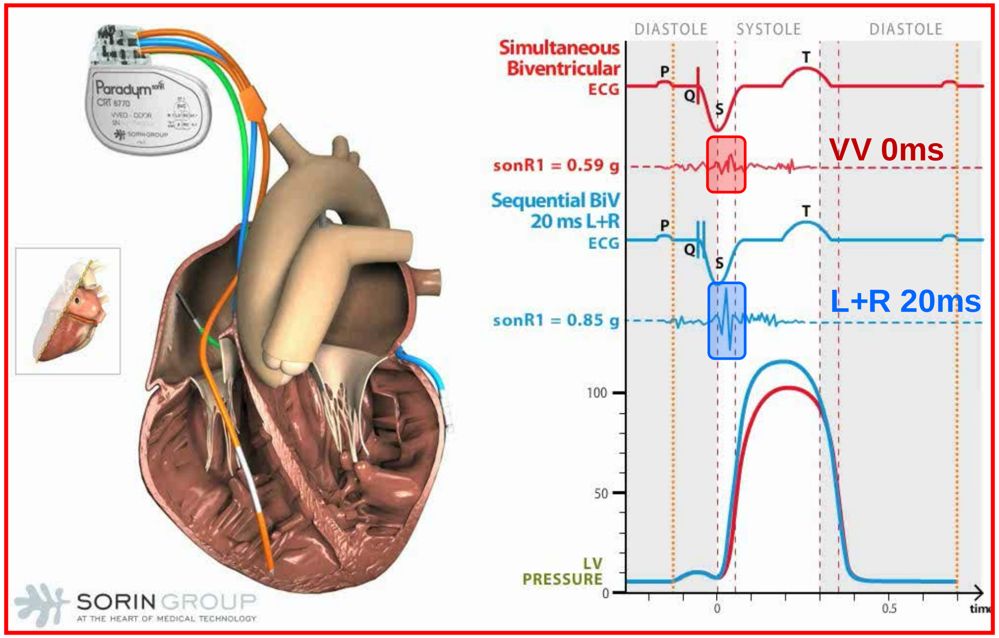
  atrium sensed: carried-out on Monday h 01:00

  atrium paced: carried-out on Monday h 02:00

- Optimization of **AVD under effort**:

  - starts searching for *Target HR* *(programmable; default 90bpm)* from h 12:00 on Monday;
  - the device optimizes only if the pt exceeds the *Target HR*

SonR algorithm: VVD optimization

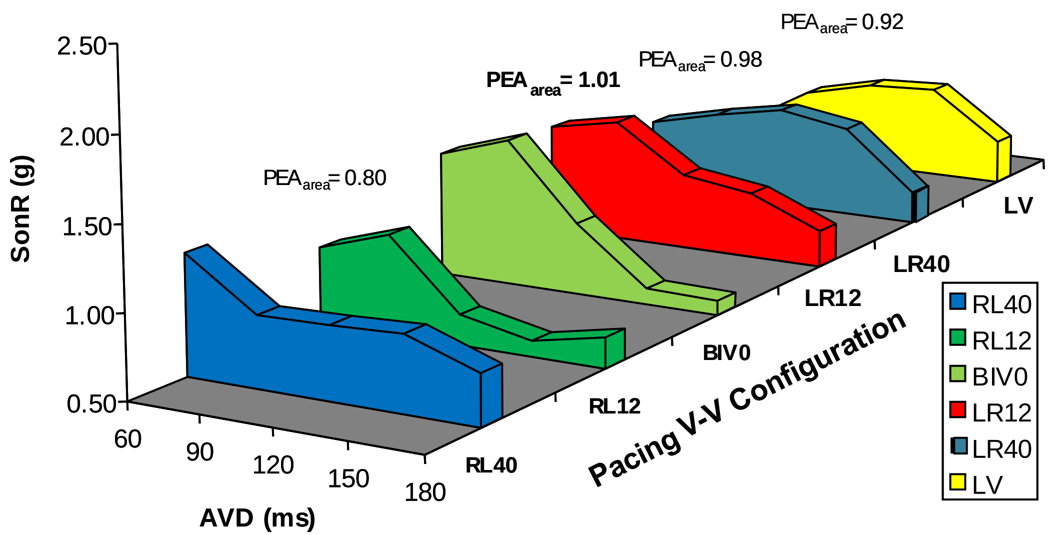


- **1st PRINCIPLE**
  modulating the VVD, the first SonR component changes accordingly
  (⇑ SonR-1 component, ⇑ myocardial contractility)

- **2nd PRINCIPLE**
  instead of taking into account a fixed AVD, for each VVD the algo measures the SonR amplitude by scanning multiple AVDs ⇒ snapshot of the **average contractility in variable volume conditions**

- **3rd PRINCIPLE (*)**
  the best VVD configuration is the one corresponding to the **highest area below the curve** (highest average contractility)

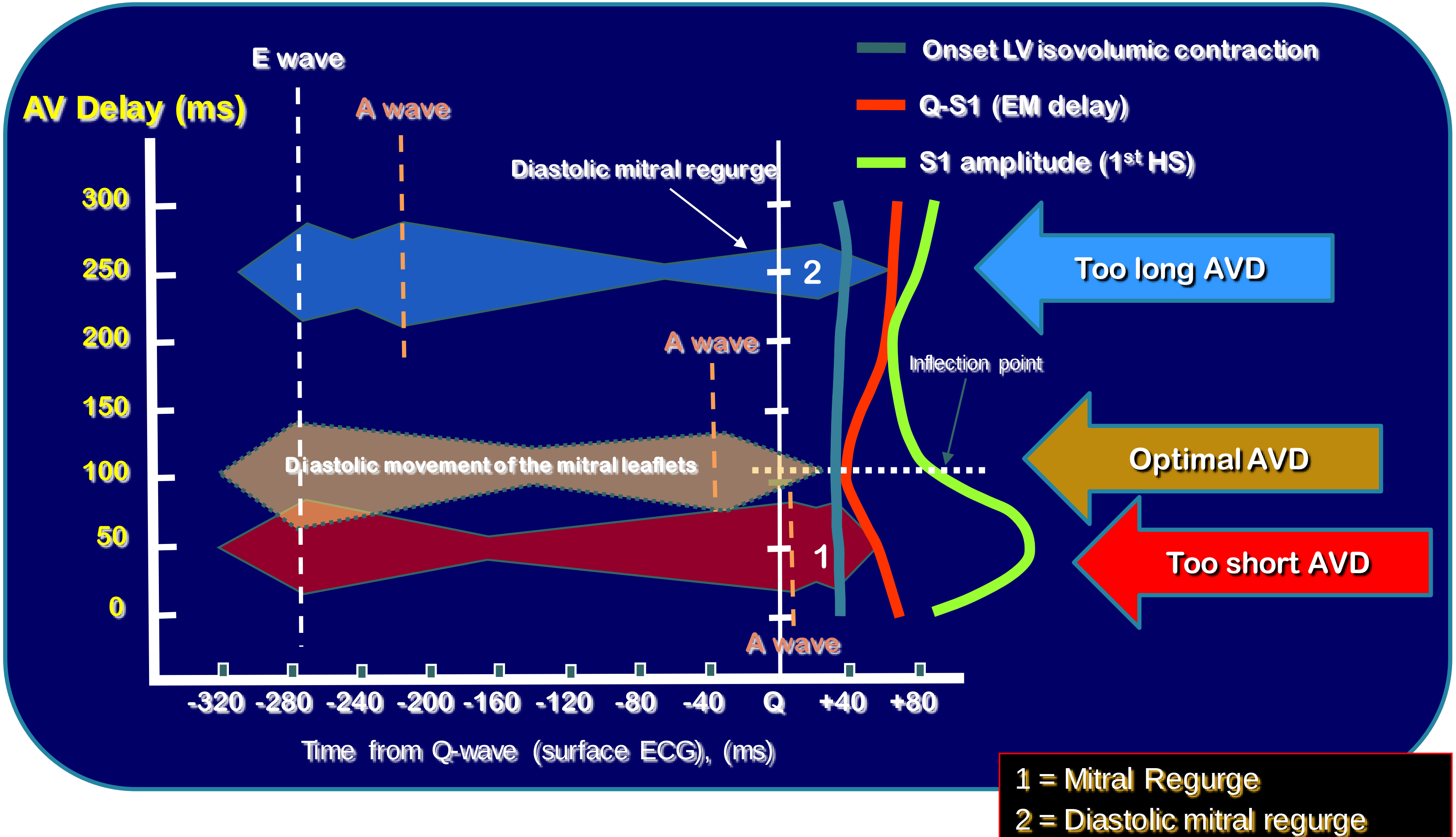
PATIENT # 7



** Delnoy PP & al. Europace. 2008 Jul;10(7):801-8*

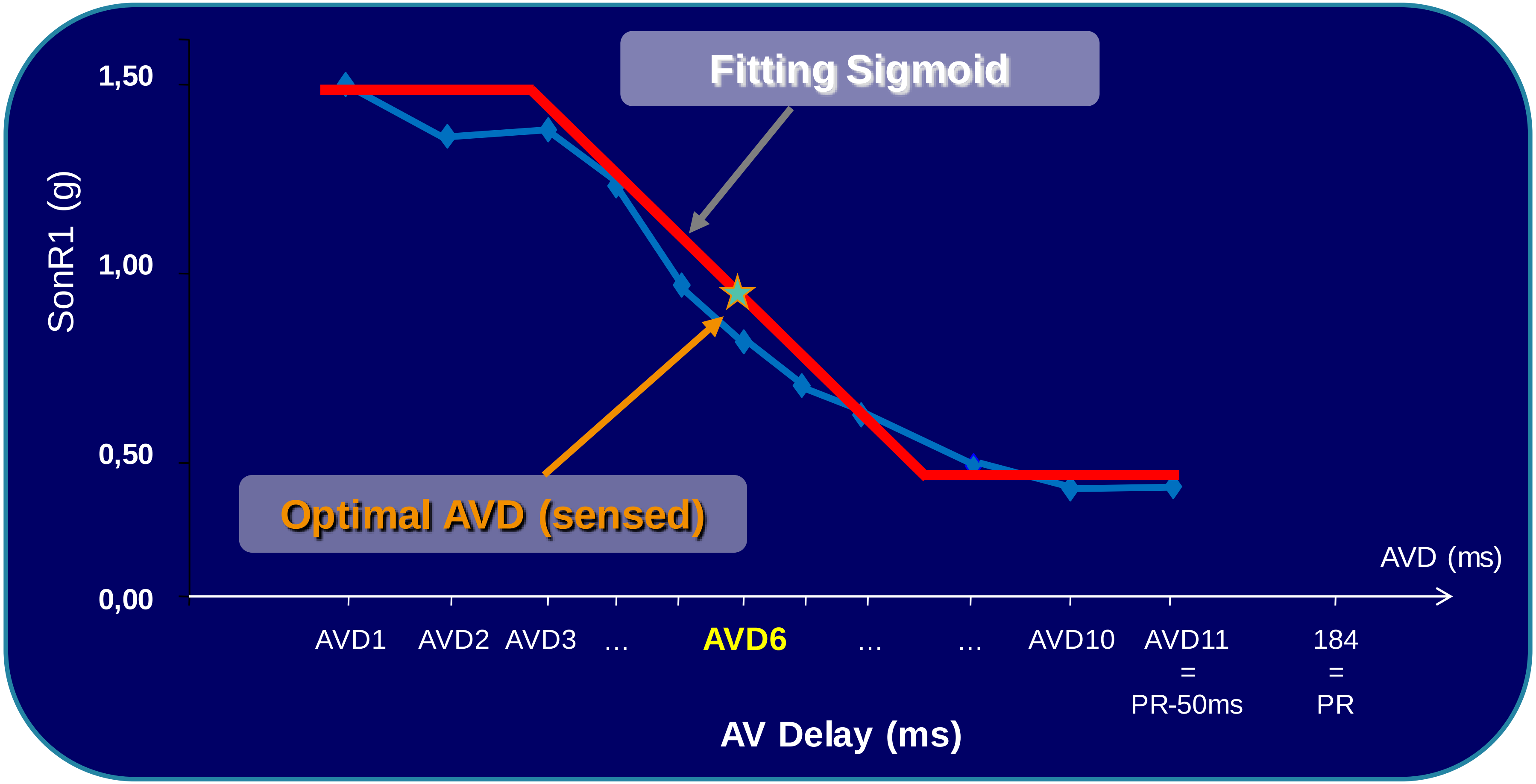
SonR algorithm:
AVD & 1st HS (= SonR)

4th PRINCIPLE
modulating the AVD value, the amplitude of 1st HS (S1) shows a typical sigmoid-shape pattern



Wexler LF & al. Circulation 1982;66:235-43

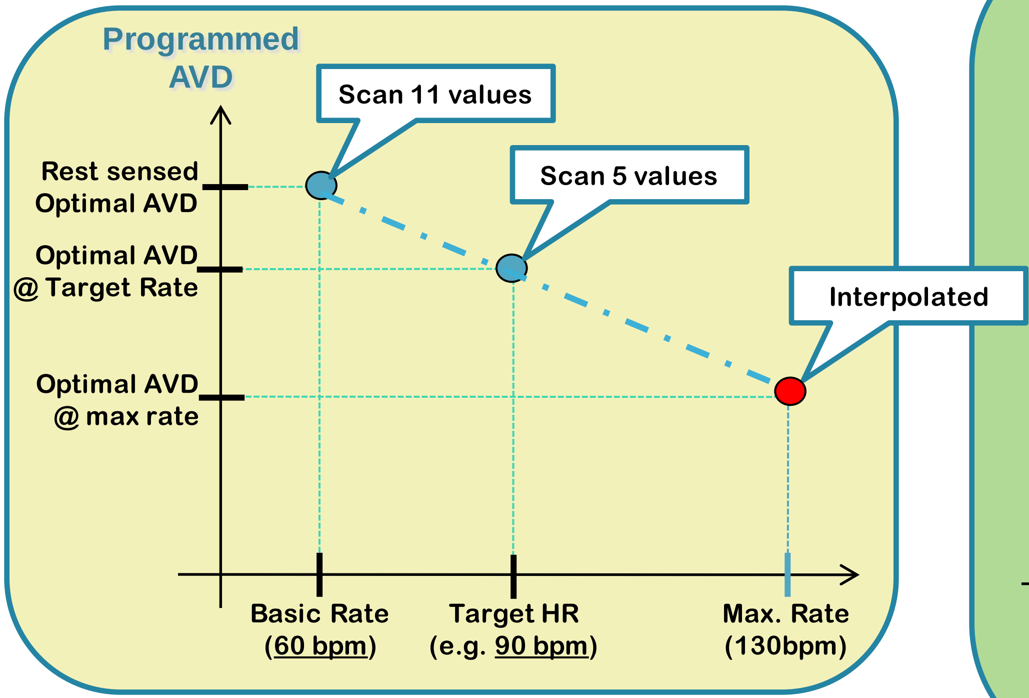
SonR algorithm:
AVD optimization *(at rest, A sensed or paced)*

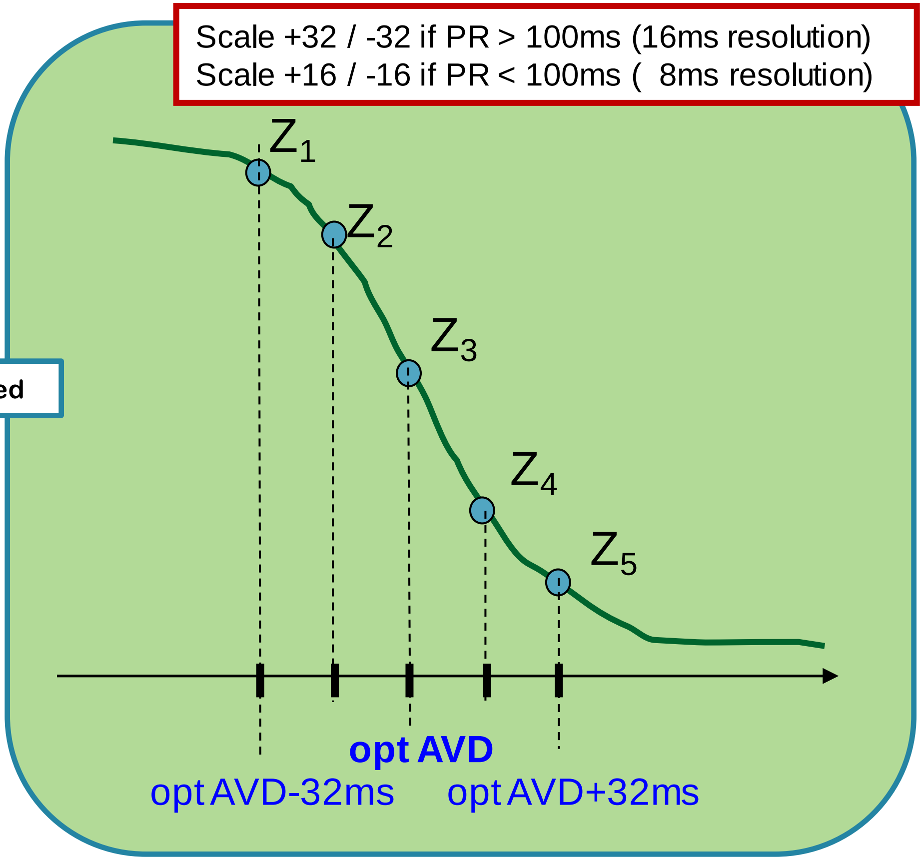


SonR vs. AVD scanning (11 values):
the algorithm picks-up the SonR values, then the fitting sigmoid is calculated;

The **optimal AVD corresponds to the inflection point of the interpolated sigmoid curve**

SonR algorithm:
AVD optimization UNDER EFFORT



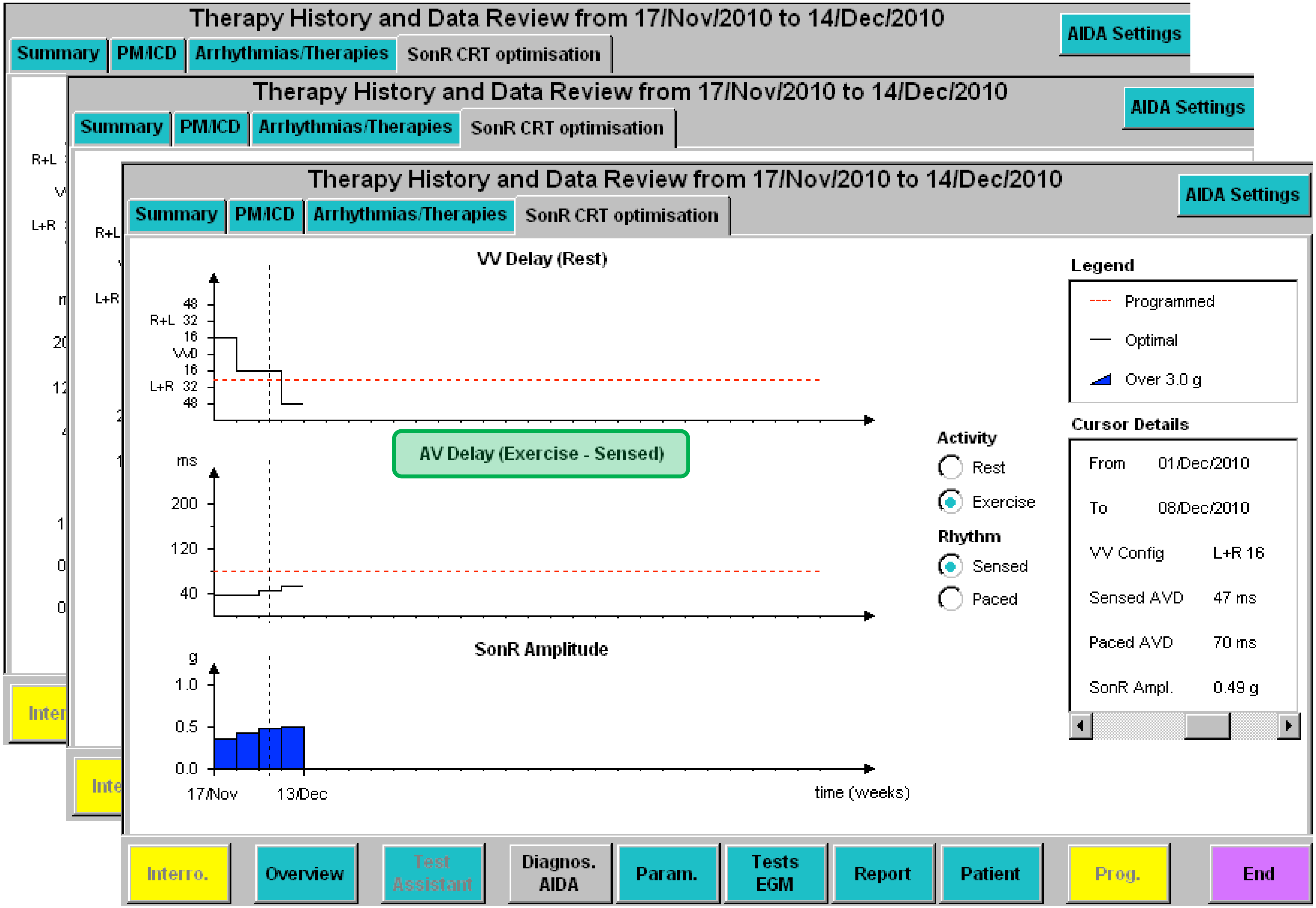


- **5th PRINCIPLE**
  If the pt exceeds the Target HR for exercise (default = 90bpm), the device worsk around the present applicable AVD value at that rate, by modulating the AVD over 5 values (to determine whether there is a shift from the optimal AVD presently programmed).

  Optimal AVD under effort ⇒ inflection point of the newly built sigmoid.

Don't worry about….

CRT device diagnostics:
Trend of optimal AVD / VVD (up to 6M, weekly)



CONCLUSIONS (1/2)

Ambulatory hemodynamic CRT optimization with SonR today

- Easy to Use (1 parameter)
- Based on hemodynamic information
- Optimization of AVD & VVD
- AVD optimization @ rest & under effort
- Automatic periodic optimization (weekly)
- (CLEAR pilot study) Improves the rate of clinical responders
- Time & cost-savings to optimize CRT settings (vs echo / alternative methods)

CONCLUSIONS (2/2)

SonR optimization algorithm:
what is the impact on pts' outcome ?

The CLEAR pilot study

Europace Advance Access published May 1, 2012

EUROPEAN SOCIETY OF CARDIOLOGY®

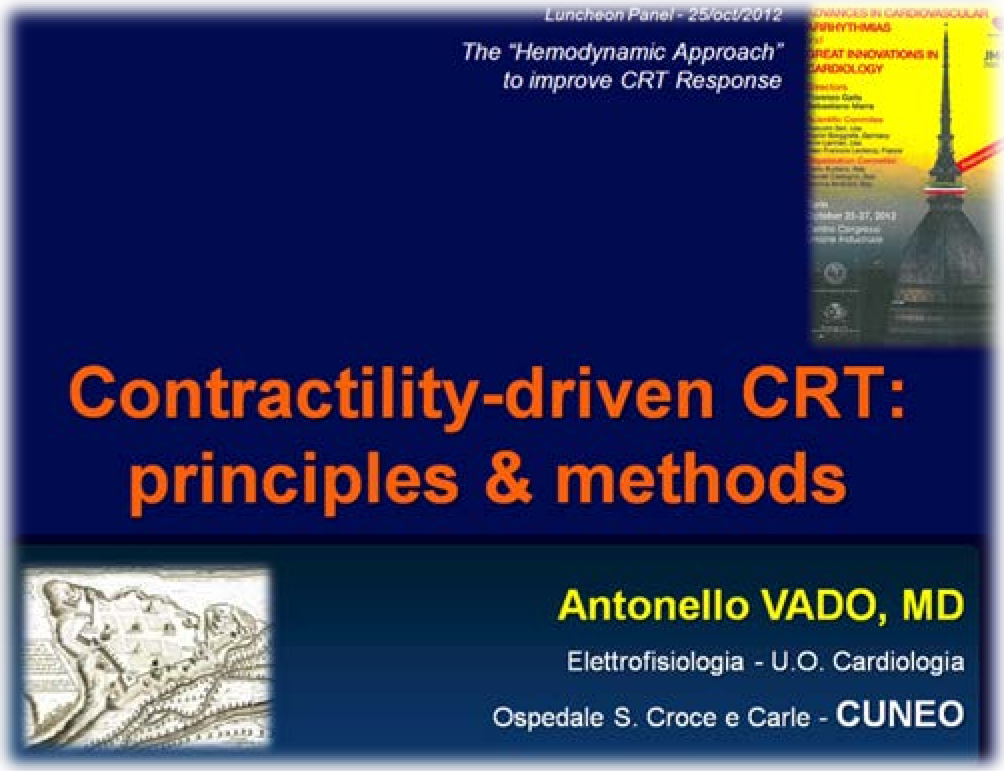
Europace
doi:10.1093/europace/eus059

CLINICAL RESEARCH

A randomized pilot study of optimization of cardiac resynchronization therapy in sinus rhythm patients using a peak endocardial acceleration sensor vs. standard methods

Philippe Ritter[1*], Peter Paul HM Delnoy[2], Luigi Padeletti[3], Maurizio Lunati[4], Herbert Naegele[5], Alberto Borri-Brunetto[6], and Jorge Silvestre[7]

Ritter P & al. Europace 2012 Sept.



Grazie dell'attenzione