AV DELAY OPTIMIZATION USING ELECTRICAL VELOCIMETRY

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Introduction

Individual AV delay optimization is essential in the follow-up of biventricular paced congestive heart failure patients and should be performed in bradycardia pacing, too. It requires easy to use and time saving methods.

Electrical velocimetry is a noninvasive method to measure changes in thoracic electrical conductivity in order to determine hemodynamic parameters. Therefore, it could be utilized to perform a serial AV delay optimization in DDD pacemaker patients. In contrast to common impedance cardiography, results of electrical velocimetry are based on a new algorithm interpreting blood conductivity changings by changing orientation of moving erythrocytes.

Figure 1: The AESCULON cardiovascular monitor (Osypka medical, Berlin, Germany and San Diego, USA).

Aims

- To test the usefulness and accuracy of electrical velocimetry to individualize optimal AV delay (AVD) in right ventricular AV block (AVB) and biventricular congestive heart failure (CHF) pacing.
- To compare results of electrical velocimetry with results of echocardiographic AV delay optimization.
- To deduce possibilities to simplify AV delay optimization during routine.

Methods

The AESCULON cardiovascular monitor (Osypka medical, Berlin and San Diego, fig. 1) was used in 19 patients (13 AVB, 6CHF, mean age 63,3±5,7years) to optimize the individual AV delay by electrical velocimetry. Serial 30s recordings were performed during VDD operation to determine maximal cardiac index. Therefore, the AV delay was decremented in steps of 20ms within a range between the pacemaker related interatrial conduction interval plus about 120ms (IACT+120ms) and the individual interatrial conduction interval.

Results were compared using an improved echo method (Fig. 2). To measure, separately, electrical and electromechanical determinants of the the optimal AV delay, we simultaneously recorded transmitral flow velocity, right atrial telemetric event markers and the filtered oesophageal left atrial electrogram (LAE).

As demonstrated in figure 2, optimal AV delay is the net effect of three electrical and electromechanical determinants. It can be calculated by the sum of

- the individual pacemaker-related interatrial conduction interval (IACT: M_A-LA in VDD, S_A-LA in DDD operation)
- the individual duration of left atrial electromechanical action ($LA\text{-}EAC_{long}$)

  reduced by
- the individuel duration of left ventricular latency period ($Sv\text{-}EAC_{short}$).

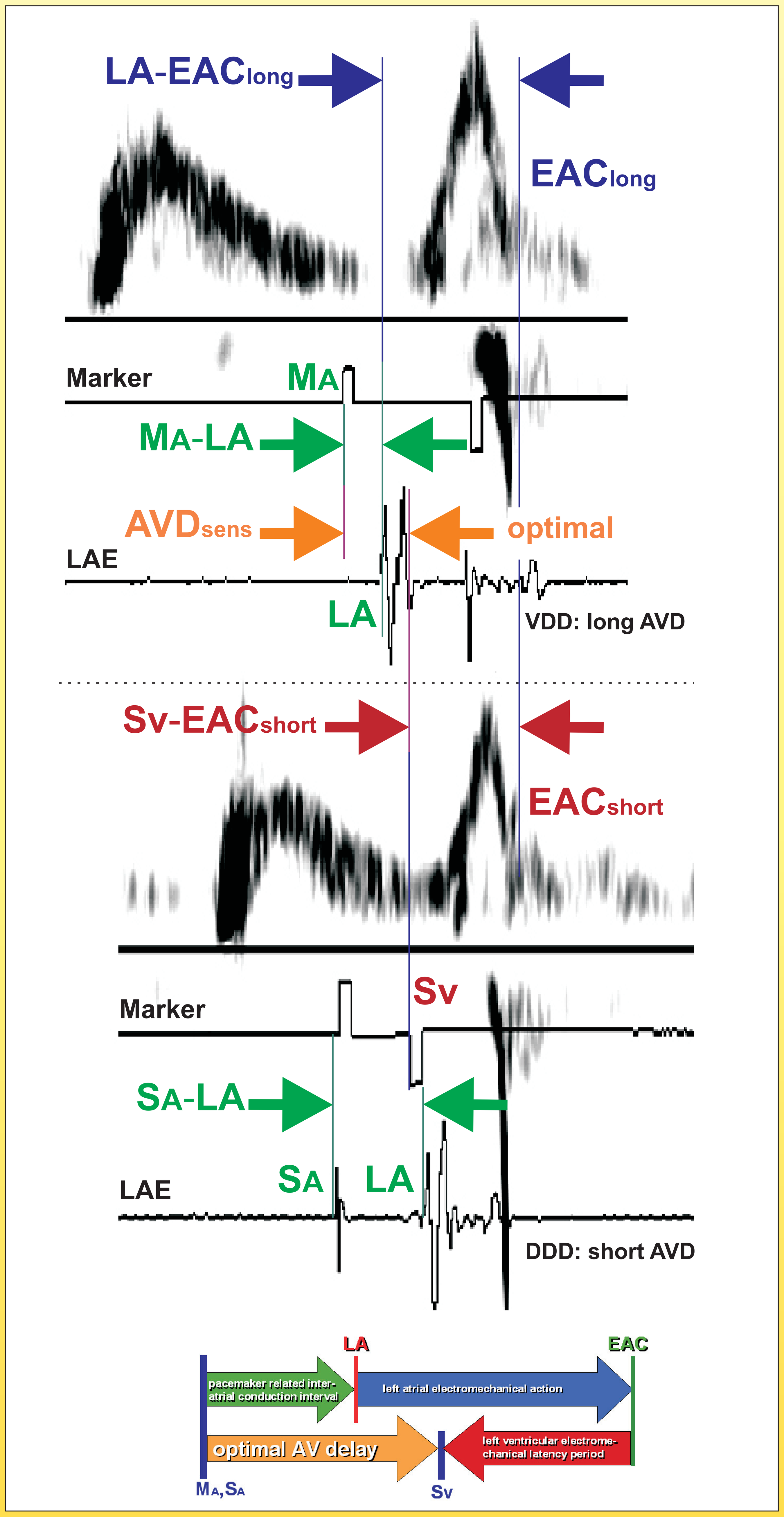

Figure 2: By simultaneous recording transmitral flow, right atrial sense event markers and the esophageal left atrial electrogram (LAE), two echo screenshots are necessary to measure the electrical and electromechanical determinats of the optimal AV delay:

Screenshot 1(top): during VDD pacing with non-physiologically long AV delay (about >120ms longer than interatrial conduction interval) we measured 1. the pacemaker related interatrial conduction interval (IACT) for VDD pacing as M_A-LA between atrial sense event (M_A) and the left atrial deflection (LA) in the LAE and 2.the duration of the left atrial electromechanical action ($LA\text{-}EAC_{long}$) between the left atrial deflection in the LAE and the end of the undisturbed left atrial controbution to ventricular filling (EAClong) which is visible in the mitral flow.

Screenshot 2 (bottum): In DDD pacing with non-physiologically short AV delay (about 20ms shorter than interatrial conduction time) we measured 3. the interatrial conduction time (IACT) as S_A-LA between atrial stimulus (SA) and the left atrial deflection (LA) in the LAE and 4. the duration of left ventricular latency period $Sv\text{-}EAC_{short}$ between ventricular stimulus Sv and the end of the prematurely ending left atrial contribution to ventricular filling (EAC_{short}).

Optimal AV delay was calculated for each mode using the formula $AVD = IACT + LA\text{-}EAC_{long} - Sv\text{-}EAC_{short}$.

Results

In all 19 patients, electrical velocimetry during VDD operation as well as the echo measurements provided an optimal AV delay.

We found mean differences between electrical velocimetry and echo of 0,32±10,3ms and a significant (p=0,01) correlation of k=0,935 between both methods (fig. 3 and 4).

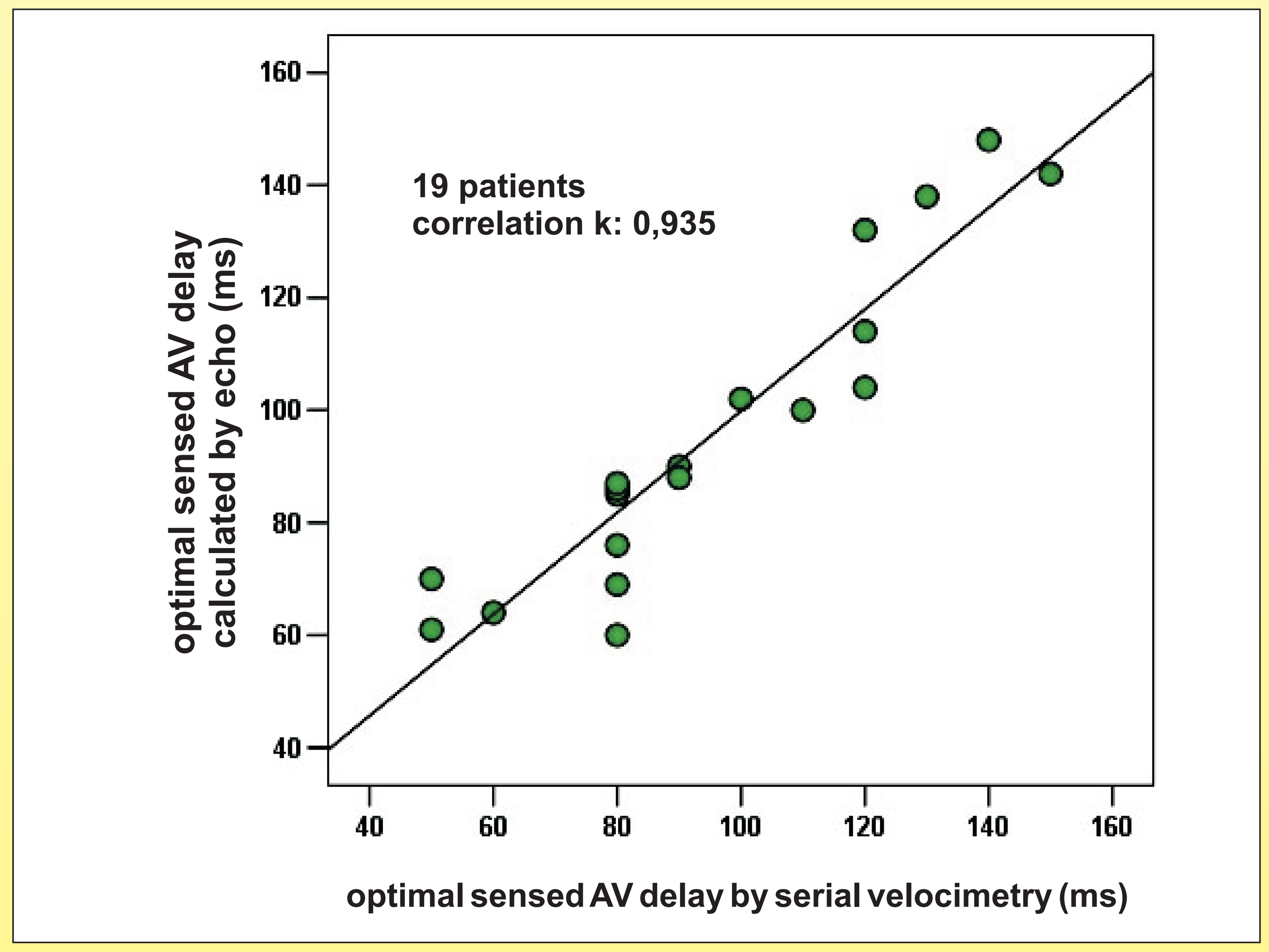

Figure 3: Comparison between results of individual AV delay optimization by electrical velocimetry and echo. Betwen both methods. We found good correllation.

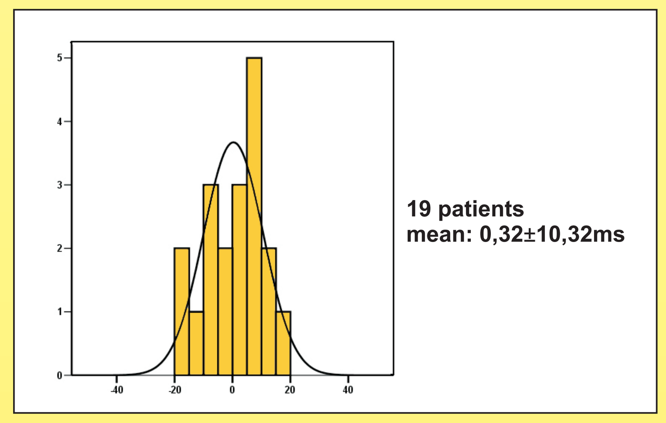

Figure 4: Histogram demonstrating the deviation of individual differences between the results of individual AV delay optimization using electrical velocimetry and echo.

Figure 5: . By knowledge of interatrial conduction intervals, any hemodynamical AV delay optimization serial methods can be reduced to either VDD or DDD operation.

Therefore, the Biotronik ICS 3000 programmer can be used in pacemaker patients irrespective of make and model to record the filtered oesophageal left atrial electrogram.

Discussion

Our study demonstrates good correllation between AV delay optimization by electrical velocimetry and by echo.

It also demonstrates the advantage of measuring interatrial conduction intervals in pacemaker patients. As shown in figure 2, the difference between optimal AV delays in DDD and VDD pacing is equal to the difference of the individual pacemaker related interatrial conduction intervals in both modes. Thus, if the latter are known, serial AV delay optimization can generally be reduced to either VDD or DDD, only. As an example, interatrial conduction intervals can easily be measured in patients with pacemakers irrespective of make and model using the Biotronik ICS3000 programmer which provides the possibility to record a filtered esophagel electrogram (fig. 5).

Conclusions

- Our study demonstrate good correlation between results of individual AV delay optimization by electrical velocimetry and by echo.
- Thus, electrical velocimetry can be utilized as a valid serial method to routinely individualize AV delay in DDD pacing for both, congestive heart failure and AV block.
- Generally, serial AVD optimization can always be reduced to either VDD or DDD mode if the individual pacemaker-related interatrial conduction intervals are known.

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