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What range of pace-sense-compensation should be provided in biventricular pacing systems for heart failure?

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Abstract

In cardiac resynchronization therapy (CRT) for heart failure, individualization of the AV delay is essential to improve hemodynamics and to minimize non-responder rate. In patients in sinus rhythm having additional disposition to bradycardia, optimization is necessary for both situations, atrial sensing and pacing. Therefore, echo-optimization is the goldstandard but time consuming. Unfortunately, it depends on the particular CRT systems parameter set if the resulting individually optimal AV delays can be programmed or not. Some CRT systems provide a set of AV delays for DDD operation combined with a set of the pace-sense-compensation to optimize the AV delay in DDD and VDD operation. The pace-sense-compensation (PSC) can be defined by the difference of implant-related interatrial conduction intervals in DDD and VDD operation measured in the esophageal left atrial electrogram. In a cohort of 96 CRT patients we found mean PSC of 59±35ms ranging between 0-143ms. As a consequence, allowing 10ms tolerance, AVD optimization is completely impossible in one of the two modes, VDD or DDD operation, in 34 (35%) or 5 (5%) patients with implants restricting the PSC range to 60ms or 100ms, respectively. Thus, we propose companies to provide CRT systems with programmable pace-sense-compensation between 0ms and 150ms.

Introduction

Patients with cardiac resynchronization therapy (CRT) for heart failure require individual optimization of the hemodynamically effective pacing parameters. Within the amount of patients in sinus rhythm having additional disposition to bradycardia, AV delay optimization is necessary for both situations, atrial sensing and pacing. To determine their hemodynamically optimal sensed (SAV) and paced AV delay (PAV), echocardiography is the goldstandard. As a disadvantage of echo and any serial AV delay optimization, these methods are time consuming. Therefore, if echo or serial methods must be excluded, the esophageal left atrial electrogramm (LAE) offers an alternative method /1/ to determine the hemodynamically optimal AV delay based on accurate measurement of the individual interatrial conduction intervals.

Nevertheless, it depends on the particular CRT systems parameter set if the resulting SAV and PAV can be programmed or not. There are systems on the market providing either independent programming of PAV and SAV or enabling programming of PAV combined with a pace-sense-compensation parameter (PSC) characterizing the difference between PAV and SAV.

Aim of this study was to ascertain the range of the pace-sense-compensation, which is necessary to hemodynamically optimize the AV delay and to cover as many CRT patients as possible in order to reduce the non-responder rate.

Methods

Generally, the hemodynamically optimal AV delay is the sum of two components. They will be separated by the left atrial deflection recording an esophageal left atrial electrogram (LAE). Starting period of the AV delay in both modes, VDD and DDD operation is the appropriate interatrial conduction interval. Duration of this interval will be fixed during right atrial electrode placement. It can be measured in VDD operation as interval As-LA between right atrial sense-event (As) and left atrial deflection (LA) in the esophageal left atrial electrogram. In DDD operation, Ap-LA is the interatrial conduction time between atrial stimulus und LA (figure 1). These intervals will be followed by an electromechanical interval LA-Vp describing the individually optimal duration of the interval between left atrial deflection and the ventricular stimulus (Vp). LA-Vp has the same duration in VDD and DDD operation. As both intervals, As-LA and Ap-LA, cannot be changed postoperatively by programming, any AV delay optimization basically consists in optimization of the Ap-LA interval, solely.

Previously reported studies have shown that the optimal AV delay in CRT pacing can be approximized by individually measuring the interatrial conduction intervals and adding about 50ms which is the mean echocardiographic result of a cohort of CRT patients /2/.

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By this way, optimal AV delay in VDD and DDD pacing can be approximated using the formula

$$\mathbf{AVD_{opt} = IACT + 50ms}$$

where the interatrial conduction time (IACT) is the duration of either As-LA (VDD operation) or Ap-LA (DDD operation) /2, 3, 4/. This equation explains that the difference between the optimal AV delay in DDD and VDD pacing equals the difference of the interatrial conduction intervals in DDD and VDD operation mode. As the individually optimal LA-Vp has the same duration in DDD and VDD operation, the pace-sense-compensation parameter PSC reflects the difference between PAV-SAV which is the difference of the interatrial conduction intervals Ap-LA and As-LA (figure 1).

Figure 1: Definition of implant-related interatrial conduction intervals As-LA in VDD pacing (top) and Ap-LA in DDD pacing (bottom). I ≙ ECG lead I, LAE ≙ esophageal left atrial electrogram, MA ≙ event-marker channel.

To perform biomedical measurements of interatrial conduction intervals in CRT patients, a measuring setup was developed utilizing the left atrial esophageal electrogram feature of the Biotronik ICS 3000 programmer. It enables perform simultaneous recordings of a three channel surface ECG, esophageal left atrial electrogram (LAE) and the telemetric right atrial electrogram (AIEGM).
Measurements were performed in 96 heart failure patients carrying either Biotronik, Medtronic or St. Jude CRT systems. In patients with Biotronic systems, IACT was measured in VDD operation as As-LA between onsets of the telemetric atrial sense-event marker (As) and LA in LAE. In patients with Medtronic and St Jude systems, IACT was calculated from the actually programmed SAV and PAV by measuring the actual interval between LA and Vp. By programming the basic about 10-20ms above sinus rate IACT in DDD operation was measured as interval Ap-LA between LA and Vp.

Results

In the cohort of heart failure patients carrying CRT systems, we found interatrial conduction intervals Ap-LA in VDD operation of 93±26ms, at mean, ranging between 60 and 221ms. In DDD operation, the interatrial conduction time As-LA was 34±28ms ranging between -23 and 100ms. As difference between Ap-LA and As-LA, the pace-sense-compensation PSC was 59±35ms differing between 0 and 143ms, at mean.
Using the results of this cohort, amount of patients will be excluded from AV delay optimization in one of the modes, DDD or VDD operation, if carrying CRT systems with PSC parameter limited to a maximum of 60ms. Allowing a tolerance of 10ms, AV delay optimization is completely impossible in one mode, either DDD or VDD operation, in 34 patients (35%). In contrast, if PSC is programmable up to 100ms, only 5 patients (5%) will be excluded.

Conclusions

To increase responder-rate in CRT patients in sinus rhythm having additional disposition to bradycardia and therefore change between VDD and DDD stimulation, we propose companies to provide a range of the programmable pace-sense-compensation between 0ms and 150ms!

4 References

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