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DEVICE ROUNDS

Atrial auto-short phenomenon as a rare cause of ventricular lead failure in a pediatric dual chamber pacemaker patient

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1 | INTRODUCTION

Closed-loop stimulation (CLS) as one form of rate-adaptive pacing synchronizes the pacing rate to myocardial contraction dynamics by using impedance monitoring on a beat-to-beat basis.[1] CLS rate adaption responds to both physical and mental stressors with good clinical performance in adult and pediatric patients.[1-4] It has been shown that DDD-CLS pacing improves ventricular function in pediatric patients with congenital complete heart block, sinus nodal disease, and in patients with recurrent vasovagal syncope.[3,5] Appropriate pacemaker timing intervals are essential to ensure adequate pacemaker function. However, standard timing interval settings may not be applied to pediatric patients as they are in need for higher heart rates compared to adult patients. Therefore, knowledge on pacemaker timing intervals and related pitfalls is crucial when treating pediatric patients with cardiac pacing devices.

2 | CASE REPORT

A female patient was implanted a transvenous dual chamber pacemaker system at 7 years of age due to sick sinus syndrome and AV block II. AVB II occurred at high and at low rates. Underlying complete atrioventricular canal was surgically corrected by 2 months of age and she received an artificial valve in mitral position. Anticipating AV conduction impairment over time we decided to implant a dual chamber pacemaker system (Epyra 8 DR-T, BIOTRONIK SE & Co. KG, Woermannkehre 1, 12359 Berlin, Germany). The pacemaker was programmed to closed loop stimulation (CLS) at a lower rate interval of 65 bpm, upper rate interval of 170 bpm, and maximum CLS track rate of 160 bpm. Detailed programming parameters are provided in Table 1. Wenckebach cycle was not tested at time of implantation. The CLS system function was fine with adequate circadian heart rate variability and appropriate rate modulation with exertion. The patient was surveyed by remote monitoring, which throughout the course of follow up reported right ventricular (RV) lead failure, causing the system to switch from bipolar to unipolar programming. Pacing demand was 85% Ap/Vs, 8% As/Vs, and 6% Ap/Vp throughout follow up. The patients' family reported no symptoms or signs of clinical impairment. The patient did not experience any sensations from unipolar pacing. We called the patient for device interrogation and detected bipolar atrial and ventricular lead impedance to show sturdy values within normal range. Electrocardiogram showed no alterations consistent with isolation defect or lead fracture. On chest X-ray lead position and integrity were impeccable. Reprogramming the device to bipolar pacing showed normal thresholds, impedance and sensing parameters. Figure 1 shows the electrocardiogram (EGM) tracing during RV lead failure detection. What can be noticed from Figure 1?

3 | DISCUSSION OF FIGURE 1

EGM tracing shows atrial pacing at a rate of 160 bpm with intrinsic conduction to the ventricles. The pacing rate equals the maximum CLS track rate. Atrioventricular interval (AVI) seems rather long and atrial pacing is annotated as atrial refractory sense (Ars) due to the short

ventriculo-atrial interval (VAI) with the atrial pace falling within the postventricular atrial refractory period (PVARP). Although paced AVI was programmed to 150 ms, what causes the AVI to extend to 300 ms in the tracing? What may be the cause of RV lead failure detection?

We hypothesized that timing parameters may inflict automatic RV impedance measurement. AVI was extended to 300 ms by intrinsic rhythm support (IRSplus). Pacing occurred at the maximum CLS rate of 160 bpm (ie, 375 ms). AVI was 300 ms, VAI was 75 ms. Atrial pace is followed by a ventricular blanking (Vb) interval of 30 ms. RV lead impedance measurement occurs at 90 ms following ventricular sensing (Vs). The impulse therefore fell within the Vb interval leading to failure of impedance measurement and causing RV lead failure (Figure 2). How could this timing problem be solved?

4 | COMMENTARY

Careful programming of pacemaker systems in regard of timing intervals is crucial as many pitfalls may arise (eg, Pacemaker mediated tachycardia, impaired ventricular function, and left ventricular filling, 2:1 block response). Recently Silvetti et al[6] have shown that atrial CLS pacing using transvenous as well as epicardial leads is effective in young patients with operated complex congenital heart defects (CHD). Atrial CLS pacing should be considered an alternative. Using epicardial leads might save dual chamber device, as well as transvenous lead associated complications. However, in our case, we agreed on implanting a transvenous DDD system due to already impaired AV conduction and prior mitral valve replacement.

Pediatric patients need higher heart rates compared to adults and rate adaptive pacing may play an important role to assure adequate growth and development.[7] However, at higher heart rates timing intervals consequently shorten and conflicts in timing may arise.

TABLE 1 Programming parameters

Mode	DDD-CLS
LRL/URL	65/170 bpm
MTR	160 bpm
Mode Switch	180 bpm
PVARP	225 ms
Atrial Threshold	1.0/0.4 (V/ms)
Ventricular Threshold	1.2/0.4 (V/ms)
Sensing A/V	Automatic
Amplitude A/V	2.2/1.7 mV
Polarity A/V	bipolar/bipolar
Impedance A/V	565/741 Ω
pAV/sAV	150/120 ms
IRSplus	ON
Rate adaptive pacing	CLS

Abbreviations: bpm, beats per minute; LRL, lower rate limit; URL, upper rate limit; MTR, maximum track rate; PVARP, postventricular atrial refractory period; A/V, atrial/ventricular; pAV/sAV, paced AV interval/ sensed AV interval; IRSplus, intrinsic rhythm support by Biotronik; CLS, closed loop stimulation.

The timing problem we here report is called Atrial Auto-Short phenomenon (AASP). AASP may rarely be encountered in clinical practice as most pacemaker patients are elderly patients with lower heart rates. AASP represents a timing problem of RV lead impedance measurement coinciding with atrial blanking. RV impedance measurement is part of the automatic lead impedance measurement, a safety feature by Biotronik. An impulse of 100 μA amplitude at 30 μs duration is emitted approximately 90 ms following a ventricular event (sensed or paced), and is repeated every 30 s. The reference range is set between 100 and 2.500 Ohm. In the occasion that impedance is measured too

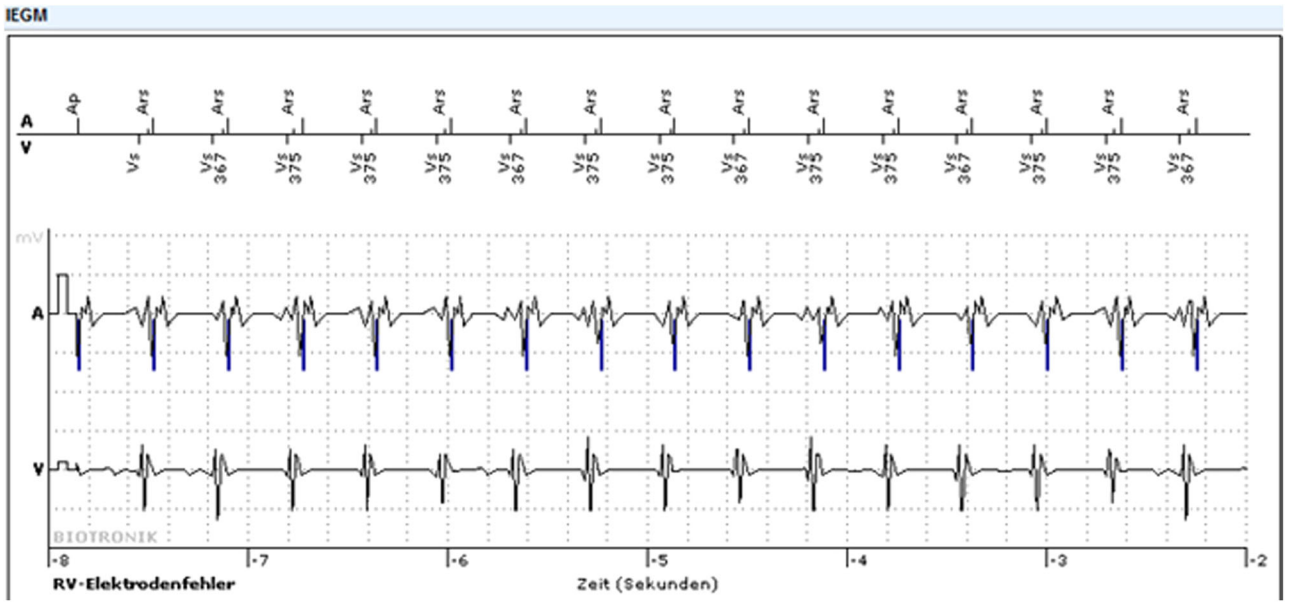

Figure 1 EGM tracing from remote monitoring during RV lead failure. Atrial pacing at maximum CLS rate of 160 ms (375 ms) [Color figure can be viewed at wileyonlinelibrary.com]

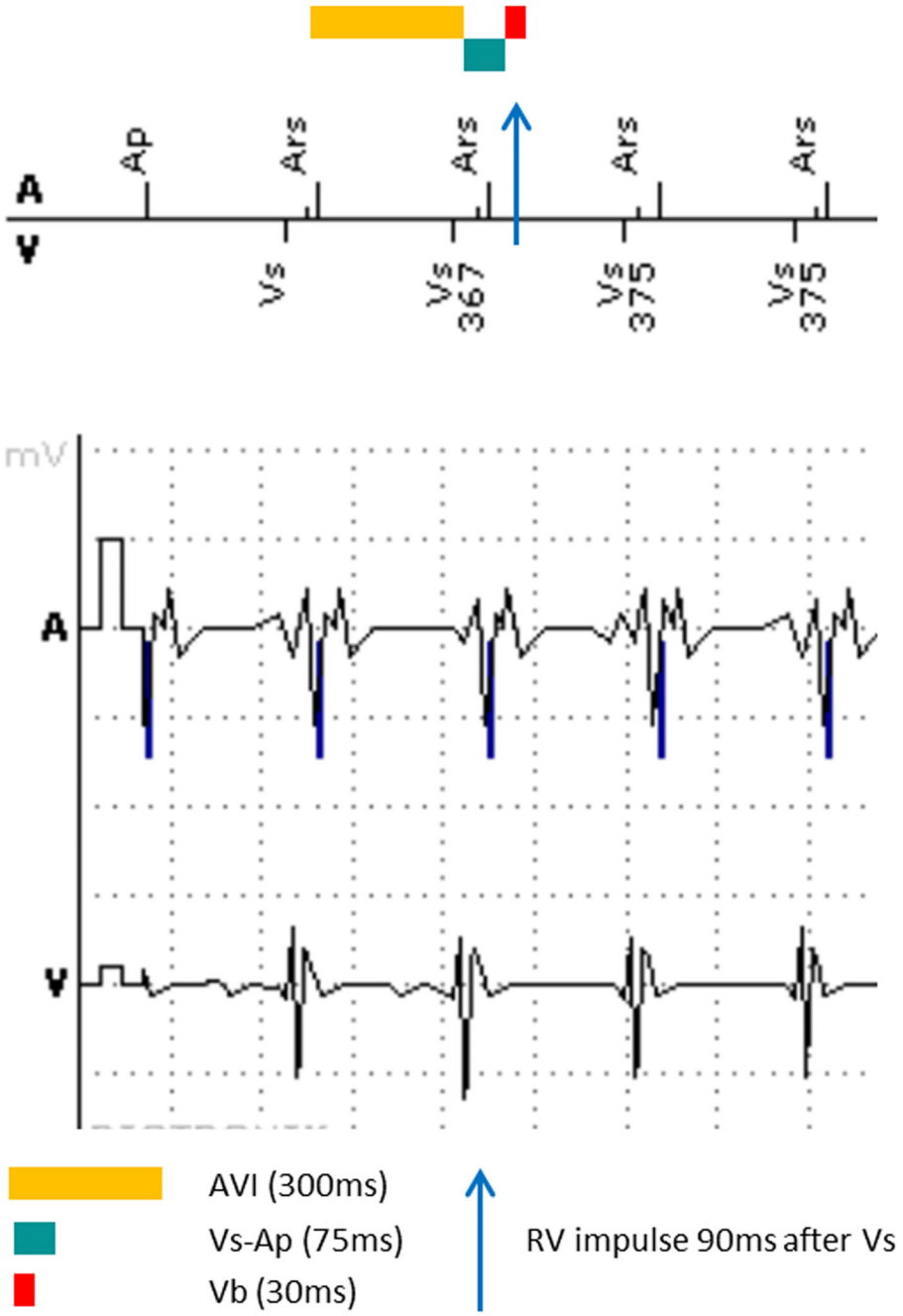

Figure 2 Timing intervals during atrial pacing at maximum CLS rate of 160 ms (375 ms) [Color figure can be viewed at wileyonlinelibrary.com]

low or high, the system automatically repeats measurement within the following two cardiac cycles. If three consecutive measurements are out of range the system defines RV lead failure and automatically switches to unipolar programming. RV impedance measurement during atrial blanking is not feasible and will result in switch to unipolar programming.

To solve this timing problem one may either reduce the maximum CLS track rate or disable intrinsic rhythm support. Both will result in impulse deliverance outside the Vb window.

In our case, reprogramming the maximum CLS track rate to 150 bpm solved the problem of RV lead failure. No more RV lead-failure reports occurred.

CLS rate should be evaluated performing exercise stress testing to uncover timing problems at higher heart rates. In our case, stress testing showed adequate intrinsic rate modulation with intrinsic AV conduction. Therefore, we could not evaluate CLS rate in terms of AV timing.

5 | CONCLUSION

When programming CLS in pediatric patients with DDD pacemakers one must be careful to set maximum CLS rate and timing parameters appropriately to avoid an atrial auto-short phenomenon. If this atrial

auto-short phenomenon occurs, decreasing maximum CLS track rate or shortening the AV interval will restore RV lead impedance measurement.

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