Left ventricular electrical delay can differentiate between ventricular and supraventricular tachycardia in cardiac resynchronization devices

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Abstract

We present an illustrative case of a patient known with both supraventricular and ventricular tachycardias. Ventricular tachycardia was characterized by 1:1 retrograde ventriculo-atrial conduction and it was difficult to differentiate supraventricular and ventricular tachycardias that were stored by her cardiac resynchronization defibrillator. Left ventricular electrical delay could differentiate between both arrhythmias. This measurement could be included in future devices for enhanced specificity of ventricular tachycardia detection.

Patients with heart failure often present with both supraventricular (SVT) and ventricular tachycardias (VT). Inappropriate therapy from implantable cardioverter-defibrillators (ICDs) often occurs in patients with SVTs. Modern ICDs have several programmable features to reduce inappropriate therapy (antitachycardia pacing or shocks) and the incidence of such unwanted and potentially harmful treatments has decreased to 3% in 2 years[1]. Two of the commonly used discriminators that can differentiate SVT from VT are atrioventricular (AV) dissociation as assessed by the presence of more R waves than P waves and morphology of near-field or far-field electrograms. Morphology is a notoriously difficult parameter and sensitivity and specificity for VT depends on threshold programming[2]. AV dissociation shows a high specificity but sensitivity depends on the absence of retrograde ventriculo-atrial (VA) conduction and it cannot be used in the presence of supraventricular tachyarrhythmias such as atrial fibrillation[1]. As a new discriminator, timing of near-field and far-field electrograms has been suggested as a very specific but less sensitive discriminator of VT and SVT[3].

1 —Case presentation:

A 57 year old female patient had recently been upgraded to cardiac resynchronisation therapy (CRT) because of progression of heart failure and development of QRS prolongation to 170ms and left bundle branch block morphology. She presented 1999 at age 37 after silent anterior myocardial infarction. In 2010 left ventricular

function had deteriorated and she received a prophylactic single chamber ICD. Also in 2010, she presented with SVT and underwent successful slow pathway ablation for presumed AV-nodal re-entry tachycardia.

Interrogation of her CRT device showed several episodes of tachycardia lasting seconds to minutes. Registration of one of these tachycardias is shown in figure 1a. Her device labelled this as SVT. There was 1:1 relation of atrial and ventricular depolarizations and based on this registration, both VT with 1:1 retrograde conduction or SVT with antegrade A-V connection were possible. The patient had an RA-RV delay of 170ms and an RV-LV delay of 100ms during normal sinus rhythm (figure 1b), comparable to the presenting tachycardia. In addition to the tachycardia in figure 1a, the patient exhibited tachycardias that could be correctly classified. She had VTs with a cycle length comparable to the presenting tachycardia as demonstrated in figure 2. This tachycardia starts with VA dissociation (3 fast ventricular beats without acceleration of the atrial rhythm. From the third beat of the VT there was retrograde VA conduction but during 1:1 period of the tachycardia, the delays were profoundly different with an RA-RV delay of 220ms and and RV-LV delay of 0ms. Figure 3 shows start and end of an SVT, most likely focal atrial tachycardia even though atypical (slow retrograde and fast antegrade) AV nodal re-entry tachycardia cannot complete be ruled out. During this SVT RA-RV delay was 160ms and RV-LV delay 100ms, comparable to the situation during normal sinus rhythm. Based on RV-LV timing the tachycardia from figure 1a could also be diagnosed as SVT.

2 —Discussion:

ICD technology has progressed in recent years with improved battery longevity and additional programming capabilities leading to fewer inappropriate and unnecessary shocks. Inappropriate shock therapy has implications for patients' quality of life. In addition, randomized trials have demonstrated that smart programming can also decrease mortality showing a link between unwanted ICD therapy and cardiovascular endpoints[4].

To reduce inappropriate ICD therapy it is mandatory to discriminate between SVT and VT. In addition to single-chamber ICD discriminators sudden onset, stability of RR intervals and morphology from near-field or far field intracardiac signals, dual chamber ICDs have the possibility to analyse P wave and R wave relations. The presence of more R than P waves has a very high specificity for presence of VT. In patients with a 1:1 relation of P and R waves it is difficult for the ICD (and the cardiologist) to differentiate VT from SVT. Specificity of morphology discrimination is dependent on programmed threshold but also sampling frequency of the intracardiac signals. Timing intervals, however, can be very accurately measured by ICDs and pacemakers. Most VTs show different timing intervals between RV and LV than SVTs. LV sensing has gained interest in the recent years as CRT-Ds from several manufacturer's including Biotronik (Biotronik SE & Co. KG, Berlin, Germany) can store IEGMs from all three channels during tachycardias demonstrating dissimilarities between RV and LV rhythms ins some cases[5]. In addition, LV sensing can complicate biventricular pacing because the device has to negotiate three different timing cycles that can lead to unwanted suppression of biventricular pacing[6].

We propose that RV-LV timing could be introduced as a novel discriminator between SVT and VT in CRT devices. Pacemakers and ICDs can measure timing intervals very precisely and it is possible that specificity is higher than that of morphology that is currently. In addition, in current Biotronik CRT-Ds it is not possible to use morphology as an VT discriminator.

Figure legends

Figure 1a: registration of monitored tachycardia from Biotronik CRT-D demonstrating signals from all three channels: A: atrium, RV: right ventricle, LV: left ventricles. Cycle length of the tachycardia is 390ms. A-RV delay is 170ms, RV-LV delay is 100ms.

Figure 1b: Intracardiac registration from Biotronik CRT-D demonstrating signals from all three channels: A: atrium, RV: right ventricle, LV: left ventricles as well as far-field ECG (FF) from the right ventricular coil to the device. A-RV delay is 170ms, RV-LV delay is 100ms.

Figure 2: registration of start and end of monitored tachycardia from Biotronik CRT-D demonstrating signals from all three channels: A: atrium, RV: right ventricle, LV: left ventricles. Cycle length of the

tachycardia is 390ms. A-RV delay is 220ms, RV-LV delay is 0ms.

Figure 3: registration of start and end of monitored tachycardia from Biotronik CRT-D demonstrating signals from all three channels: A: atrium, RV: right ventricle, LV: left ventricles. Cycle length of the tachycardia is 390ms. A-RV delay is 160ms, RV-LV delay is 100ms.

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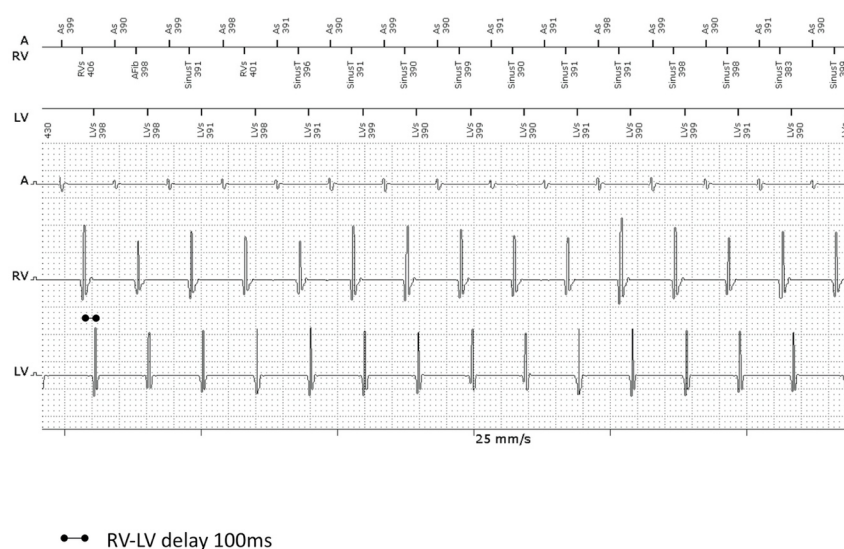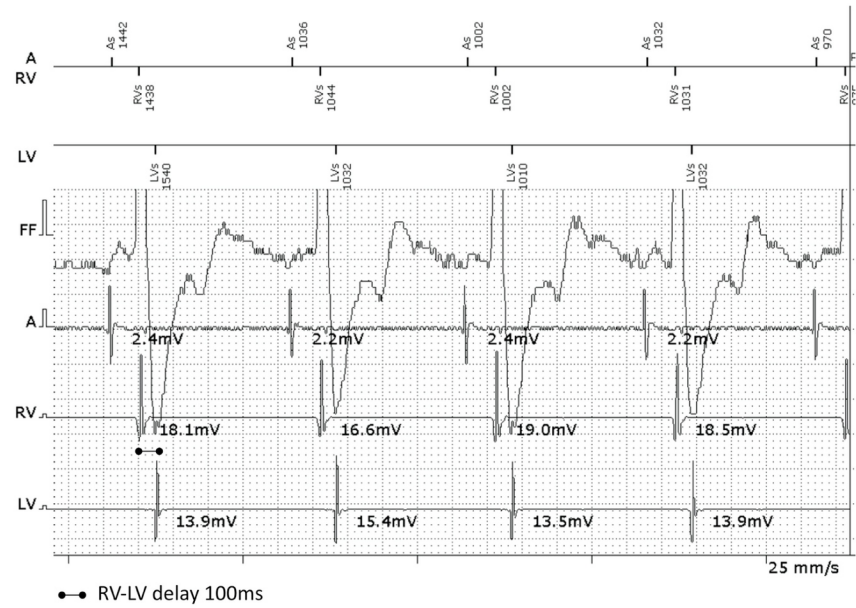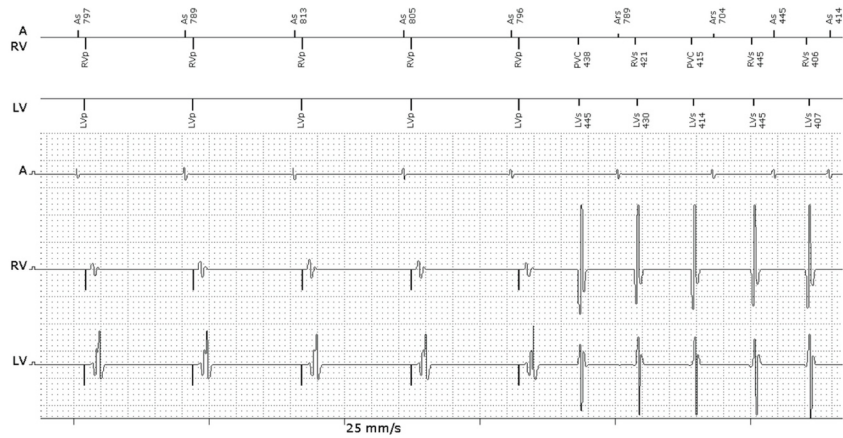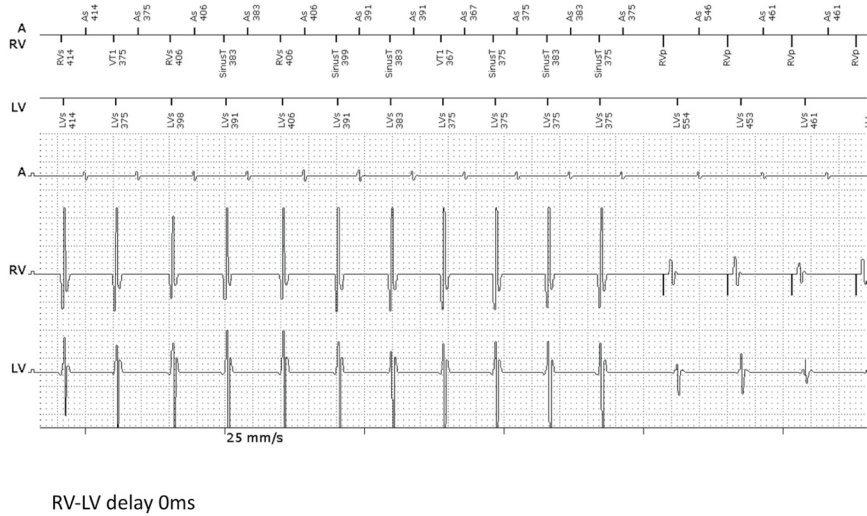
Figure 1a

●—● RV-LV delay 100ms

Figure 1b

RV-LV delay 100ms

Figure 2

RV-LV delay 0ms

Figure 3

● ● RV-LV delay 100ms

● ● RV-LV delay 100ms

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RV-LV delay 100ms

RV-LV delay 0ms

RV-LV delay 100ms