ECG Challenge Response

ECG Response: November 12, 2013

ECG Challenge: A 65-year-old man with a known idiopathic dilated cardiomyopathy treated with a β-blocker, angiotensin-converting-enzyme inhibitor, spironolactone, and daily diuretics was recently admitted to another hospital for decompensated heart failure that occurred while he was visiting his daughter. Upon returning, he presented to his cardiologist for a follow-up visit and reports that he had a surgical procedure performed, but he does not know any further details.

The rhythm is for the most part regular, but there are 2 longer RR intervals noted (↔). The rate is 110 bpm. The QRS complex duration is increased (0.12 s). Although it has a morphology that resembles a right bundle-branch block, with a tall R wave in V1 (↓) and terminal S waves in leads V5-V6, it is not a typical looking right bundle-branch block. In addition, the axis is indeterminate (ie, between −90° and ±180°; negative QRS complex in leads I and aVF). It cannot be established whether this is an extreme right or extreme left axis. An indeterminate axis is not seen with conduction through the normal His-Purkinje system. With a wide QRS complex, it indicates direct myocardial activation, as occurs with a ventricular complex, preexcited complex or a paced complex.
The QT/QTc interval are slightly prolonged (360/490 ms) but are normal when the prolonged QRS complex duration is considered (340/450 ms). Because the QT interval includes the QRS complex as well as the ST segment and T wave, prolongation of the QRS complex duration needs to be considered when establishing the QTc interval. The amount of widening of the QRS complex that is above the normal width needs to be subtracted from the QT interval measurement before the QT is corrected for heart rate.

Importantly, there are pacemaker stimuli seen before each QRS complex (^), especially in leads II, aVF, and V5-V6. However, the QRS complex does not have a morphology typically seen with a right ventricular pacemaker. The most important lead indicating the type of pacemaker (ie, right ventricular versus biventricular pacemaker) is lead I. Lead I is the only bipolar right-left lead. An impulse originating from the right side and traveling to the left (as with a right ventricular pacemaker) will result in a broad R wave in lead I (and a left bundle-branch block–like pattern). In contrast, this ECG has a QS complex in lead I (†), indicating that the impulse is originating on the left and traveling toward the right. This indicates that there is biventricular (left ventricular) pacing present. Also suggesting a biventricular pacemaker is the tall R wave in lead V1 (↓) (although this may be seen with a right ventricular pacemaker electrode at the septum) and the QS complex pattern in lead V5-V6 (although this may be seen with a left bundle-branch block).

There are P waves (+) before each of the paced QRS complexes, with an atrial rate of 110 bpm. Therefore the pacemaker is functioning in a P-wave synchronous or A-sensed V-paced mode. However, the P waves are negative in leads II, aVF, and V4-V6. Hence, this is not a sinus tachycardia, but, rather, it is an atrial tachycardia. The 11th QRS complex is premature (•) and has a different morphology; hence, this is a premature ventricular complex.

Although there is a P wave before each QRS complex, the PR interval is not constant. It can be seen that the PR interval gradually prolongs from 0.14 to 0.22 s (▼). The long RR interval or pause is the result of 1 on-time but nonconducted P wave (▲), after which the PR interval shortens to the baseline length of 0.14 s. This is a pattern of Mobitz type I or Wenckebach, and, with a paced rhythm, it is known as pacemaker-mediated or pseudo Wenckebach. The occurrence of this pattern is related to 2 programmable features (ie, the postventricular atrial refractory period [P-V ARP]), which determines the upper rate limit of the pacemaker (the fastest atrial rate sensed or tracked by the pacemaker resulting in a ventricular stimulus) and the atrioventricular delay of the pacemaker (ie, the time delay between sensed atrial activity that is either paced or spontaneous and the delivery of the ventricular stimulus). These 2 parameters define the total atrial refractory period. If there is an underlying atrial rate that is close to the upper rate limit of the pacemaker, the atrial impulse is still sensed by the atrial channel (as the atrial impulse occurs after the P-VARP). If the atrial impulse is sensed, the pacemaker is committed to deliver a ventricular stimulus (unless it is inhibited by a spontaneous ventricular complex). However, if, based on the atrioventricular delay, delivery of a ventricular stimulus would violate the upper rate limit of the ventricular channel, the pacemaker waits until the upper rate limit is achieved before the ventricular stimulus is delivered. After the ventricular stimulus is delivered, the P-VARP starts again. If there is a stable atrial rate, the next atrial impulse is now closer to the P-VARP; and, therefore, there is even a longer time before the ventricular stimulus can be delivered, accounting for a lengthening of the atrioventricular delay. This continues until the atrial impulse coincides with the P-VARP and is no longer sensed; hence, there is no ventricular stimulus (ie, there is a nonconducted P wave).

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