OVERVIEW OF THE ECG

This ECG shows a regular, wide complex paced rhythm (QRS 132ms) with a ventricular rate of 84bpm. This patient has a dual chamber pacemaker with sensed P waves followed by paced QRS complexes.

MORE DETAILED ANALYSIS OF THE ECG

The paced QRS morphology and QRS axis are the keys to determine the type of ventricular pacing (Figure 1).

This paced QRS morphology has a rSR' pattern in V1 and a qR pattern in V6 (resembling an atypical right bundle branch block (RBBB) pattern). The QRS duration is wide (132ms) with rapid initial activation. The rapid r wave in V1 and q wave in V6 suggests rapid conduction towards the left ventricular (LV) apex and R' in V1 suggests delayed activation to the right ventricle (RV). The paced QRS axis has an inferior axis (75 degrees).

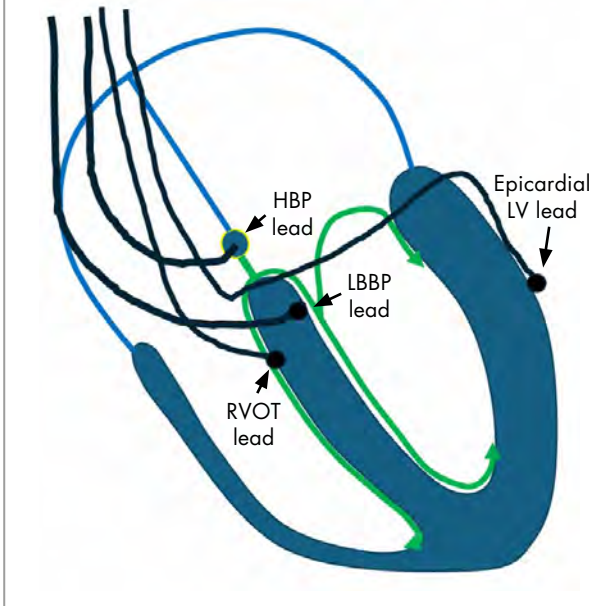

FIGURE 1: Different lead positions for different types of ventricular pacing. HBP = His bundle pacing, RVOT = right ventricular outflow tract, LBBP = left bundle branch pacing, LV = left ventricular. Cardiac resynchronisation therapy = biventricular pacing (pacing from both right ventricular lead and epicardial LV lead simultaneously).

Right ventricular outflow tract (RVOT) pacing usually causes a wider QS or rS pattern in V1 and V2 (atypical left bundle branch block (LBBB) morphology) because depolarisation is moving away from V1 and V2 with an inferior QRS axis. The activation is delayed throughout the QRS complex because of slow cell-to-cell depolarisation.

Biventricular pacing / cardiac resynchronisation therapy (CRT) results in simultaneous RV and LV pacing following a sensed or paced P wave (with a short PR interval). CRT-paced morphology can be highly variable between patients because of different positions of the RV and LV leads. A qR or Qr pattern in lead I is usually indicative of CRT pacing with a QRS duration between 120ms and 200ms (typically narrower than either RV or LV pacing) with a north-west axis.

Epicardial / coronary sinus pacing usually causes a very wide QRS morphology (epicardial pacing results in very wide QRS complexes because impulses proceed from the outer LV) with a dominant R wave in V1 with usually right axis deviation when pacing the lateral LV wall.

RV outflow tract pacing, biventricular pacing and epicardial / coronary sinus pacing can therefore be excluded based on the QRS morphology and axis.

His bundle pacing (HBP) involves pacing the His bundle only (selective His capture) or His bundle and local myocardium (non-selective His capture). Selective His capture usually produces a narrow QRS (similar to the conducted QRS) in the absence of bundle branch block with a normal QRS axis. Non-selective His capture produces a pseudo delta wave (due to local myocardial capture) with an initial widening of the QRS with a normal axis. While non-selective His capture is possible in this ECG because of the lack of an isolelectric baseline after the pacing spike, we are told that the presenting ECG showing complete heart block with a LBBB junctional escape, this would not explain the atypical RBBB pattern in V1.

Left bundle branch area pacing (LBBAP) refers to capture of the left subendocardial area of the interventricular septum and comprises:

- Left bundle branch pacing (LBBP) where there is capture of the left bundle branch (LBB) i.e. conduction system capture occurs.

- Left ventricular septal pacing (LVSP) where there is capture of ventricular muscle on the left interventricular septum without capture of the LBB i.e. no conduction system capture occurs.

LBBP, like HBP, therefore provides a form of physiological pacing. Growing evidence suggests that LBBP may reduce the risk of pacing-induced cardiomyopathy and heart failure admissions compared to RV pacing.[1] LBPP may also be a suitable alternative to CRT.[2]

Both LBBP and LVSP can cause an atypical RBBB pattern (qR or Qr pattern) with a normal axis. However, differentiating between LBBP and LVSP can be challenging as the pacing morphology can appear similar on a 12 lead ECG. Detailed measurements are often needed on a faster paper speed with the use of digital callipers in the cath lab at the time of implant. In general, LBBP results in a narrower QRS complex and more rapid QRS activation compared to LVSP. These changes are best seen and measurements made in the cath lab on an EP recording system.

There have been numerous proposed criteria to help differentiate LBBP from LVSP.[3] The best evidence for LBBP includes morphology changes in V1 and V6 when transition occurs between LBBP and LVSP during threshold testing. The speed of activation from pacing to apical lead V6 measured as the R wave peak time (RWPT) from pacing spike to R wave in V6 is a useful measurement (see Figure 2). The RWPT typically prolongs in V6 by >15ms when LBBP transitions to LVSP (this occurs because activation to the apex is faster with LBBP because of conduction system capture). A RWPT <75ms has also been shown to be accurate for confirming LBBP. In this case the RWPT was 45ms confirming LBBP (Figure 3). Another useful measurement is the V6-V1 inter R wave peak interval with longer intervals confirming LBBP (as RWPT is typically short resulting in longer V6-V1 times). A V6-V1 interval >44ms is specific for LBBP. The V6-V1 interval was measured as 46ms (91ms - 45ms) confirming LBBP (Figure 4).

The correct answer is (c) Conduction system pacing – left bundle branch pacing.

DISCUSSION

Conduction system pacing, which includes HBP and LBBP, is a physiological alternative to RV pacing for bradycardia pacing for the prevention of pacing-induced cardiomyopathy and as an alternative to traditional CRT for heart failure with left LBBB.

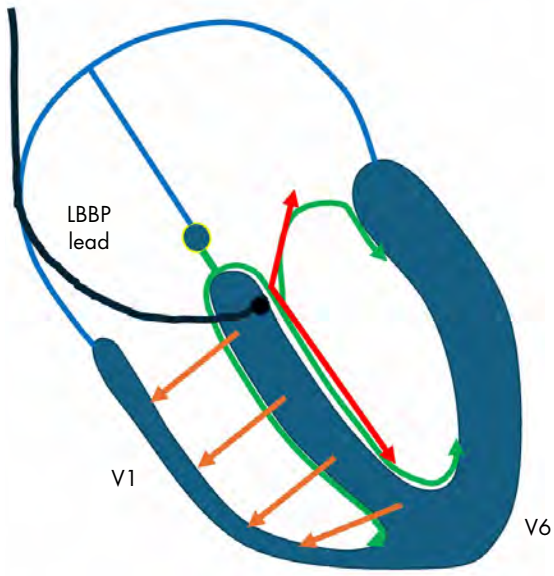

FIGURE 2: With left bundle branch pacing (LBBP), conduction capture occurs which causes rapid activation down both fascicles to the apical lead V6 (red arrows) resulting in a very short R wave peak time (RWPT). Right ventricular depolarisation follows later (orange arrows), resulting in a qR wave in V1 with a delayed R wave peak time. In LVSP, no conduction capture occurs which results in a longer RPWT in V6 with similar R wave peak time in V1 which results in a longer V6-V1 interval.

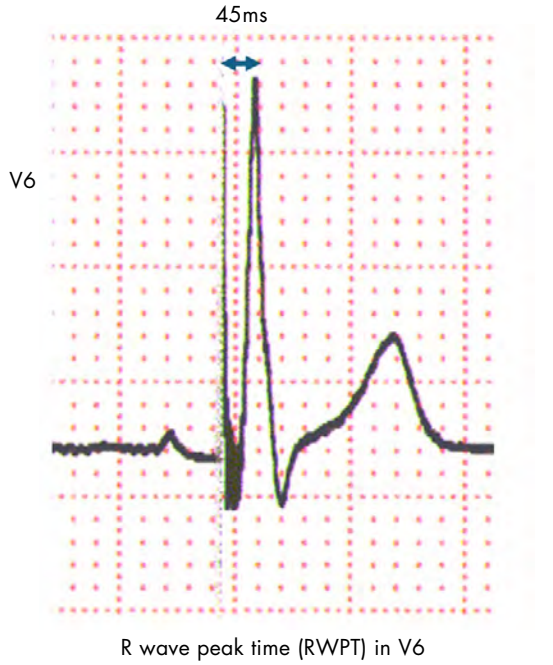

FIGURE 3: R wave peak time (RWPT) in V6 is measured from the pacing spike to the R wave. A RWPT <75ms is specific for LBBP. RWPT = 45ms in this patient confirming LBBP.

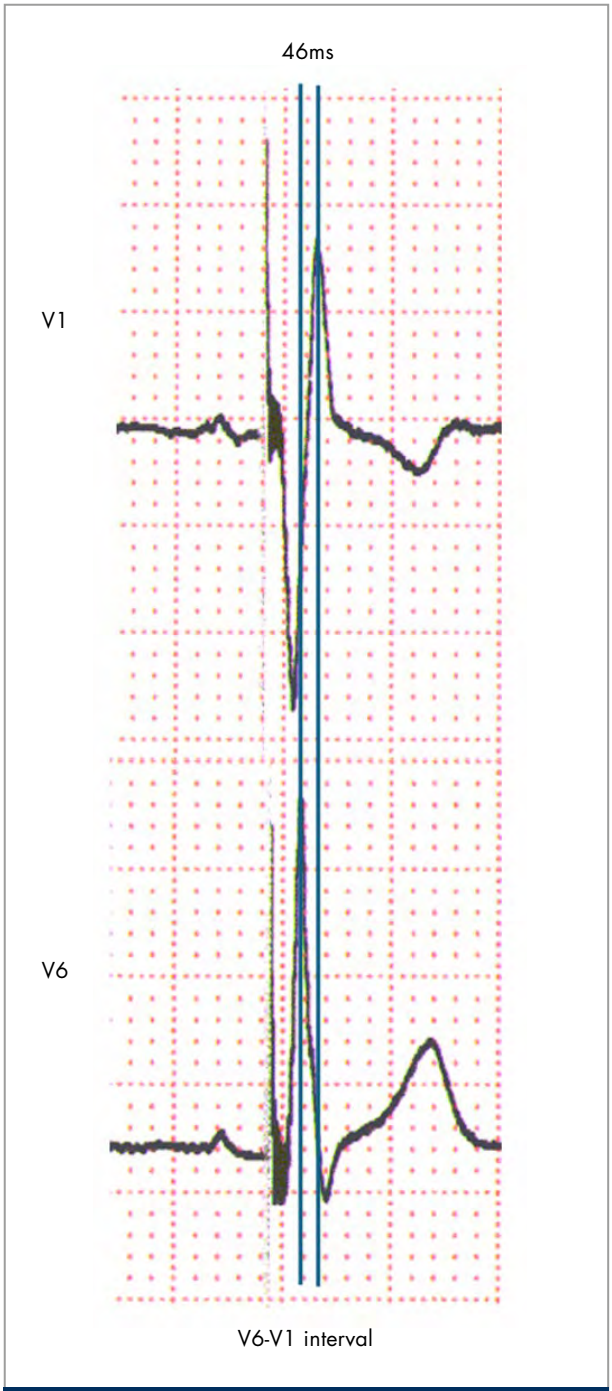

FIGURE 4: The V6-V1 interval is the interval between the R wave in V6 and the R' wave in V1. A V6-V1 interval >44ms is specific for LBBP. V6-V1 interval = 46ms in this case confirming LBBP.

Disadvantages of HBP include high capture thresholds, lead stability with a high risk for lead repositioning. LBBP has gained popularity over HBP due to several advantages. LBBP has low capture thresholds and leads tend to be more stable with a larger target area and has the ability to correct distal conduction disease.

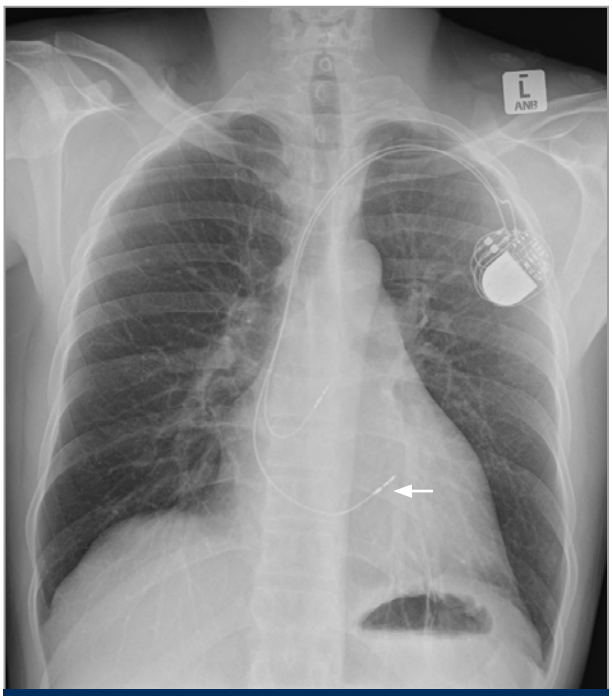

FIGURE 5: A PA chest X-ray showing position of the right atrial lead and the left bundle pacing (LBBP) lead. The LBBP is fixed in the high interventricular septum using an active fixation lead (white arrow).

LBBP is performed by advancing a guiding catheter into the RV 1.5 - 2cm from the His bundle towards the apex. The lead is then rapidly rotated and advanced into the interventricular septum. The lead is advanced until LBBP is achieved before perforation into the LV occurs. LBBP must be distinguished from LVSP before the sheath is slit and the lead secured. An X-ray showing lead positions is shown in Figure 5.

While the indications for LBBP are evolving, the strongest indications for LBBP include the following:

- LBBP may be considered for the treatment of heart failure as a bailout or alternative to conventional CRT.
- LBBP may also be considered for bradycardia pacing for AV block when the anticipated high burden of ventricular pacing and LV dysfunction is present.
- LBBP may also be considered as part of a pace and ablate strategy for rate control for atrial fibrillation and AF with heart block with a high percentage anticipated RV pacing.

Pacemaker follow-up is very important to ensure persistent LBBP. A 12 lead ECG is important and should be compared to the post implant ECG. It is not uncommon for a patient to return with LVSP and lack of LBBP at follow-up visits. Careful

pacemaker interrogation should be performed to confirm both LBBP and LVSP thresholds.

This patient had good LBBP thresholds at the 6 week visit.

CONCLUSION

LBBP is a relatively new form of physiological pacing which is gaining popularity worldwide and in South Africa as an alternative to conventional CRT and for some bradycardia indications.

Careful analysis of the ECG is essential to confirm LBBP and careful threshold testing confirming LBBP is mandatory at every device follow-up visit.

The classic ECG of LBBP is an atypical RBBB morphology with a rapid RWPT in V6. Careful analysis is required at the time of implant to distinguish LBBP vs. LVSP.

Implanters need to be able to differentiate LBBP from LVSP as LVSP appears not to have the same benefits of LBBP.

Conflict of interest: none declared.

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