Circulation

CASES AND TRACES

Alternating Bundle-Branch Block

What Is the Mechanism?

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ECG CHALLENGE

A 37-year-old woman with non-Hodgkin lymphoma undergoing chemotherapy and no other significant medical history was incidentally noted to have an irregular heart rhythm on physical examination, and a 12-lead ECG was obtained. ECG (Figure 1) showed sinus rhythm with alternating pattern of right bundle-branch block (RBBB) and left bundle-branch block (LBBB). What is the mechanism of the alternating bundle-branch block pattern noted on the ECG?

1. Alternating RBBB and LBBB premature ventricular contractions
2. Alternating phase 3 block in the bundle branches
3. Alternating phase 4 block in the bundle branches
4. Interpolated premature ventricular contractions with alternating bundle-branch morphologies

Please turn the page to read the diagnosis.

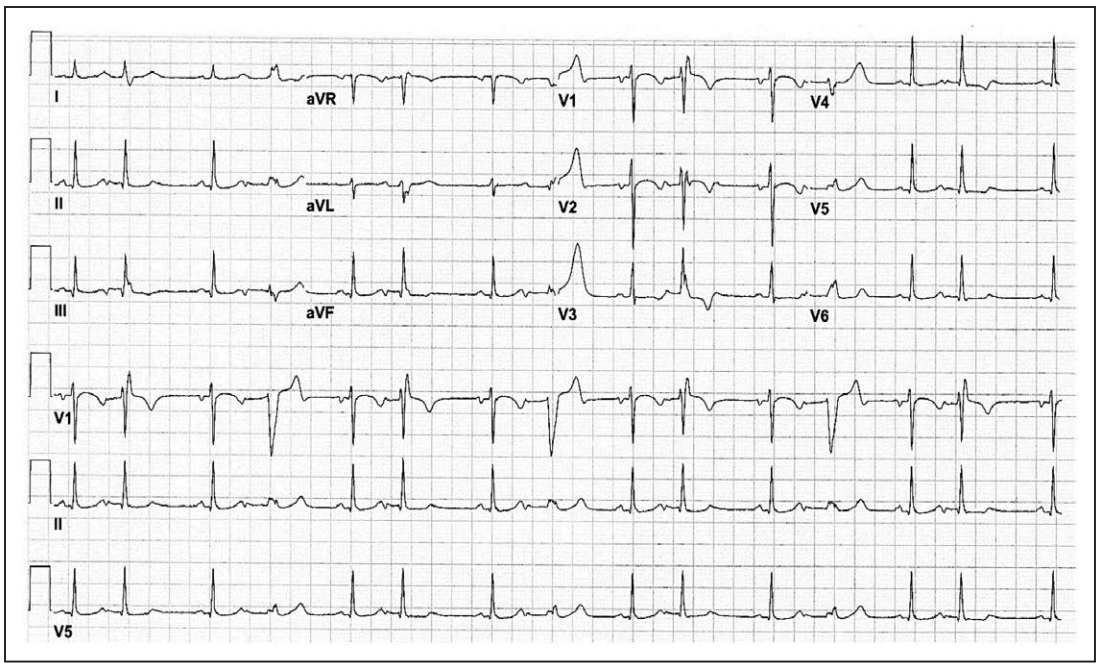

Figure 1. Twelve-lead ECG showing sinus rhythm with alternating right and left bundle-branch block pattern of ventricular conduction.

RESPONSE TO ECG CHALLENGE

Irregular heart rhythm in this patient is the result of frequent atrial ectopic beats occurring in a bigeminal fashion. P waves are seen within the preceding T waves during ectopy, and the atrial coupling interval is constant (440 ms), which confirms that these are premature atrial complexes (PACs) and not premature ventricular complexes. Each PAC conducts to the ventricles, and the resultant QRS complexes are wide with an alternating pattern of RBBB and LBBB aberrancy. As depicted in the single-lead ECG strip (precordial lead V1 in Figure 2), the first P wave is a sinus P wave that is conducted normally down to the ventricles, as evidenced by a normal PR interval (120 ms) and narrow QRS duration. What follows next is a PAC (blue dot), which falls within the T wave and is able to conduct to the ventricles with a longer PR interval (200 ms) and RBBB aberrancy (PAC finds right bundle refractory and conducts down the left bundle). It is noteworthy that the block in right bundle (RB) may not necessarily be absolute, but is more likely a result of a relative delay of conduction between left bundle (LB) and RB. The third P wave is a sinus P wave and is conducted normally to the ventricles. The fourth P wave is a PAC occurring at the same coupling interval, but conducts to the ventricle with an even longer PR interval (280 ms) and LBBB aberrancy. This cycle of atrial bigeminy with alternating RBBB and LBBB aberrancy continues over the remaining strip. The ladder diagram (Figure 2) depicts our explanation for the ECG findings.

Aberrant conduction is present when there is an alteration in the QRS contour of supraventricular beats resulting from impulse transmission during periods of physiological refractoriness or depressed conductivity. This can be acceleration-dependent (phase 3) aberrancy or deceleration-dependent (phase 4) aberrancy. The aberrant conduction in this case is a result of prematurity and is thus acceleration-dependent (phase 3 block). In addition, the refractory periods of the bundle branches are dependent on the preceding cycle lengths. These properties are critical in explaining the variability in aberrancy. Because, under normal circumstances, the refractory period of RB is longer than that of LB, RBBB aberrancy is more common, specifically in patients without conduction system disease.

In this case, despite the identical coupling interval of the PACs, there is an alternating shift of relative conduction delay between the bundle branches. The sec-

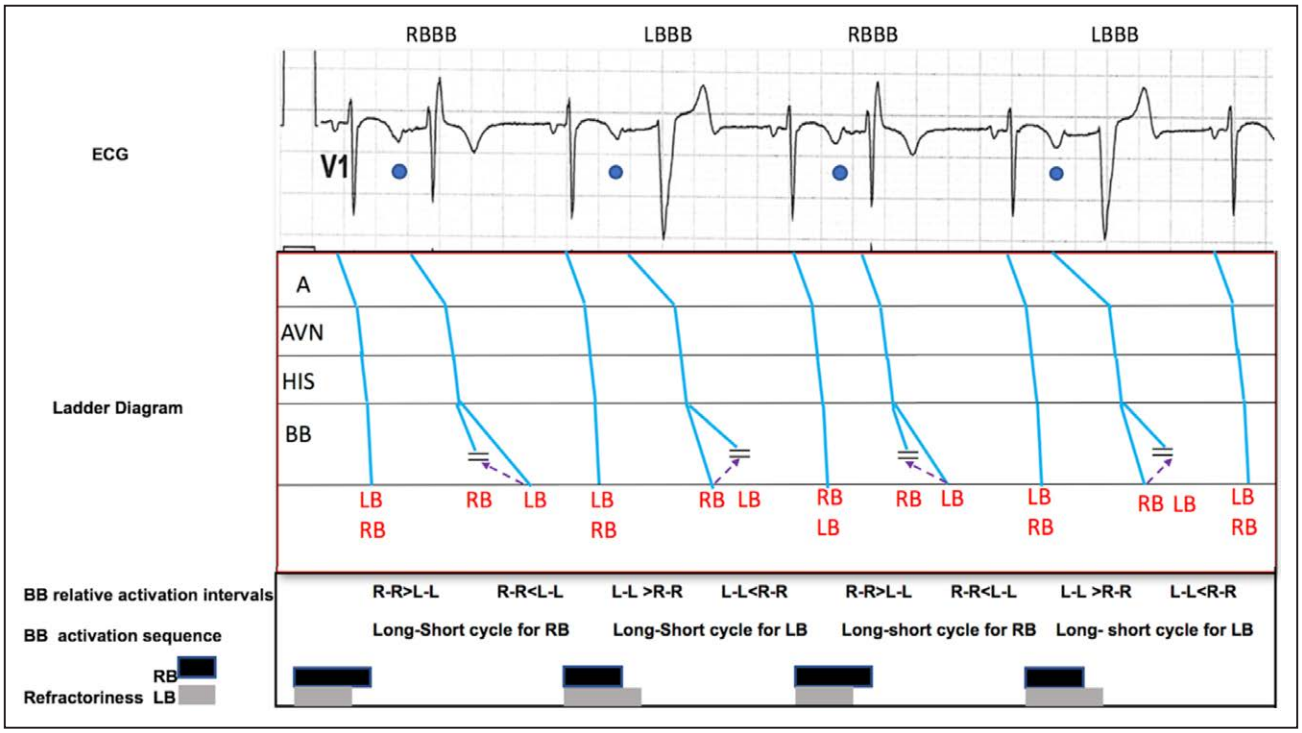

Figure 2. Diagrammatic description of mechanism of alternating bundle branch block.
Top, Depiction of the ECG precordial lead V1 in our patient, showing atrial bigeminy with PACs marked by blue dots and an alternating pattern of aberrantly conducted QRS complexes during ectopy interspersed by normally conducted sinus beats. **Middle,** Details of the electric circuit with aid of a ladder diagram. Solid blue lines mark the antegrade conduction, and dotted purple lines indicate retrograde concealed conduction. **Bottom,** Description of the bundle-branch activation intervals, long-short activation sequences, and relative change in bundle-branch refractory periods. A indicates atrium; AVN, AV node; BB, bundle branches; His, His; LB, left bundle; LBBB, left bundle-branch block; PAC, premature atrial complex; RB, right bundle; and RBBB, right bundle-branch block.

ond P wave is a PAC that conducts down the LB (resulting in a RBBB pattern), then via transseptal conduction conceals retrogradely into the RB, resulting in delayed activation of the distal RB. This is followed by a sinus beat that conducts down both the bundle branches without aberrancy. The sinus beat establishes a longer cycle length for the LB than the RB (because the LB was activated earlier on a prior premature beat in comparison with RB), thereby resulting in greater prolongation of the LB refractory period than RB. The subsequent PAC then finds the LB relatively refractory because of the long-short sequence in LB and preferentially conducts down the RB (resulting in a LBBB pattern), then conceals retrogradely into the LB. This pattern of long-short cycles in the distal His-Purkinje system results in alternating bundle-branch block. This phenomenon of alternating bundle-branch block has been previously reported[1–3] and is the result of relative functional delay of conduction in the distal His-Purkinje system during prematurity and does not necessarily indicate the presence of a diseased conduction system.

ARTICLE INFORMATION

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Disclosures

None.

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