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ADVANCED

IMAGING VIGNETTE: ECG CHALLENGE

Wandering Bundles With Sinus Arrhythmia

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ABSTRACT

A 3-year-old boy with congenital ventricular septal defect underwent a closure procedure. Telemetry after the procedure reveals sinus arrhythmia with varying types of bundle branch blocks. Inverse decremental conduction in left posterior fascicle, related to preceding RP interval during sinus arrhythmia, underlies changes between right and left bundle branch blocks. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2023;15:101856) © 2023 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

A 3-year-old boy with congenital ventricular septal defect (VSD) with a diameter of 6.3 mm, which was located at the 10 to 11 o'clock position of the parasternal short-axis view and 7 mm below the aortic valve ring on echocardiography, was electively admitted for a transcatheter closure procedure. His preprocedure 12-lead electrocardiogram (ECG) revealed sinus rhythm without conduction abnormalities. During percutaneous transcatheter closure of VSD, the patient developed transient third-degree atrioventricular (AV) block but regained his baseline sinus rhythm with normal AV conduction quickly. The patient did well and denied chest pain, shortness of breath, palpitation, and lightheadedness or syncope after the procedure. Telemetry ECG on day 3 after the procedure is shown in **Figure 1A**.

QUESTION: REGARDING VARYING QRS MORPHOLOGIES, WHAT IS THE MOST LIKELY MECHANISM?

A. Phase 3 block in the right bundle branch
B. Phase 4 block in the left bundle branch
C. Decremental conduction in the left anterior fascicle
D. Inverse decremental conduction in the left posterior fascicle

The correct answer is D.

The ECG displays sinus rhythm with sinus arrhythmia and different PR intervals ranging from 150 ms to 200 ms. The AV conduction wanders from complete right bundle branch block (RBBB) plus left anterior fascicular block (LAFB) to complete left bundle branch block (LBBB) with different transition types, including incomplete RBBB plus LAFB, isolated LAFB, and incomplete LBBB. RBBB appears to occur after a relatively shorter RP interval during sinus arrhythmia, indicating possible phase 3 block in the right bundle branch

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ABBREVIATIONS AND ACRONYMS

AV = atrioventricular

ECG = electrocardiogram

LAFB = left anterior fascicular block

LPF = left posterior fascicle

LBBB = left bundle branch block

RBB = right bundle branch

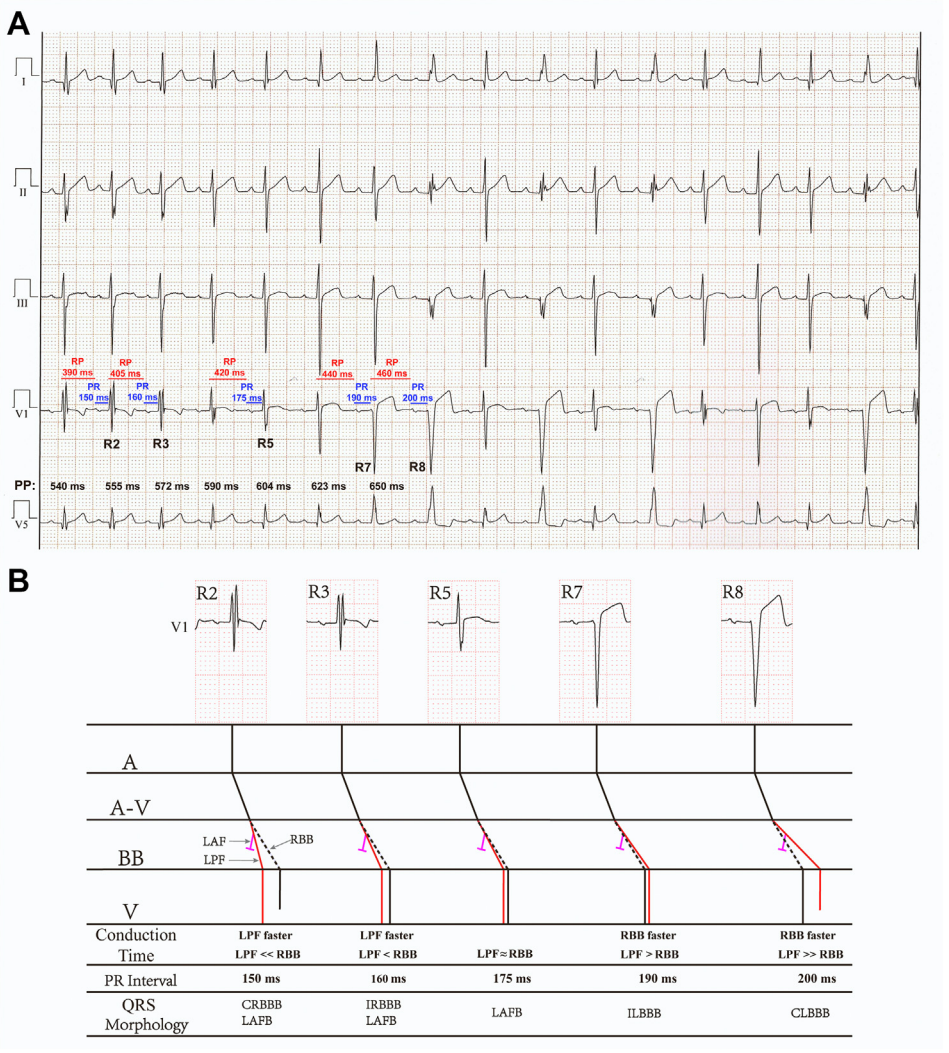
RBBB = right bundle branch block

VSD = ventricular septal defect

(Choice A). However, it can't explain isolated LAFB and LBBB. Phase 4 block (Choice B) is a potential differential diagnosis for the observed ECG phenomena. But gradual QRS duration shortening from complete RBBB to isolated LAFB in response to gradual PP or RP interval prolongation during the first 5 beats can't fit into phase 4 block hypothesis. In addition, occurrence of 3 transitional QRS complexes from isolated LAFB to complete LBBB within a PP interval change <50 ms also makes phase 4 block unlikely. Decremental conduction in the left anterior fascicle (Choice C) is also incorrect because LAFB in this case is not rate-dependent.

Choice D is correct. Inverse decremental conduction in the left posterior fascicle (LPF) (**Figure 1B**) can explain varying bundle branch blocks with sinus arrhythmia during which beat-to-beat changes in the RP interval influence conduction in the His-Purkinje system in subsequent beats.[1] Inverse decremental conduction, also termed as Yan conduction[2] in which conduction time is inversely correlated with upstream stimulation frequency, was first described by Yan in 2021.[1] There are 3

FIGURE 1 Yan Conduction in Left Posterior Fascicle



(A) Telemetry electrocardiogram on day 3 post=percutaneous transcatheter closure of the ventral septal defect. **(B)** The proposed mechanism for wandering bundle branch blocks. The conduction time in the left posterior fascicle (LPF) is the determinant variable for changes in bundle branch blocks. A = atria; A-V = AV node; BB = bundle branches; LAF = left anterior fascicle; RBB = right bundle branch; V = ventricles.

conduction patterns in the present case (**Figure 1B**): 1) complete conduction block in the left anterior fascicle; 2) slow, but constant conduction in the right bundle branch (RBB); and 3) inverse decremental conduction in the LPF, that is, the longer the preceding RP interval is, the slower the impulse conducts subsequently. When the LPF conducts faster than the RBB by 25 ms, the PR interval is the shortest at 150 ms and QRS complexes manifest as "complete" RBBB. In contrast, when the LPF conducts slower than the RBB by 25 ms, the PR interval prolongs to 200 ms and registers as "complete" LBBB. Varying transition types of bundle branch block are present when differences in the conduction time between the LPF and RBB vary within ±25 ms. Positive correlation of the PR interval with the preceding RP interval is shown in the Supplemental Appendix and Supplemental Figure 1. It should be emphasized that the inverse decremental conduction as the mechanism for the wandering bundle branch blocks in the present case is speculative. Phase 4 block as a differential diagnosis can't be completely ruled out. Additional differential analysis is discussed in the Supplemental Appendix.

Dynamic changes from RBBB to LBBB indicate injury in the His-Purkinje conduction system resulting from the procedure of percutaneous transcatheter closure of the VSD.[3] This patient did develop complete AV block shortly after the appearance of wandering bundle branch blocks and subsequently underwent implantation of a permanent pacemaker.

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REFERENCES

1. Yan GX. Inverse decremental conduction heralds complete atrioventricular block following transcatheter aortic valve replacement. *Heart Rhythm Case Rep*. 2021;7:820–824.

2. Zhang Y, Han Y, Liu T. A puzzling electrocardiographic phenomenon following transcatheter aortic valve replacement. *Eur Heart J Case Rep*. 2022;6:1–2.

3. Wang C, Zhou K, Luo C, et al. Complete left bundle branch block after transcatheter closure of perimembranous ventricular septal defect. *J Am Coll Cardiol Intv*. 2019;12:1631–1633.

KEY WORDS inverse decremental conduction, left bundle branch block, right bundle branch block, ventricular septal defect

APPENDIX For the supplemental appendix and figure, please see the online version of this paper.