

Approach to bradyarrhythmias: A proposed algorithm

Tiong-Cheng Yeo ^{*1,2}_{FACC}, Fang Qin Goh ^{*3}_{BMBS}, Yao Neng Teo ², Ching-Hui Sia ^{1,2}_{MBBS}

ABSTRACT

Bradyarrhythmias are commonly encountered in clinical practice. While there are several electrocardiographic criteria and algorithms for tachyarrhythmias, there is no algorithm for bradyarrhythmias to the best of our knowledge. In this article, we propose a diagnostic algorithm that uses simple concepts: (1) the presence or absence of P waves, (2) the relationship between the number of P waves and QRS complexes, and (3) the regularity of time intervals (PP, PR and RR intervals). We believe this straightforward, stepwise method provides a structured and thorough approach to the wide differential diagnosis of bradyarrhythmias, and in doing so, reduces misdiagnosis and mismanagement.

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Bradyarrhythmias are common and occur in both physiological and pathological states. Bradycardia is defined as a heart rate of fewer than 60 beats per minute, and bradyarrhythmias can be caused by sinus node dysfunction or atrioventricular (AV) conduction blocks.^{1,2} Atrial fibrillation (AF) with a slow ventricular response may also cause bradycardia. Numerous electrocardiographic (ECG) criteria and algorithms, such as the Brugada criteria, have been proposed for diagnosing tachyarrhythmias.³⁻⁵ However, there is no algorithm for bradyarrhythmias to the best of our knowledge. In this article, we propose an algorithm (Fig. 1) that uses simple concepts: (1) the presence or absence of P waves; (2) the relationship between the number of P waves and QRS complexes (i.e. whether there are more P waves compared to QRS complexes); and (3) regularity of time intervals (PP, PR and RR), to aid accurate ECG diagnosis of bradyarrhythmias.

Presence or absence of P waves

The first step of the algorithm requires the reader to check for discernible P waves. If there is no P wave, possible diagnoses include sinus arrest with junctional (narrow QRS complex, heart rate usually between 40 and 60 beats per minute) or ventricular

escape (wide QRS complex, heart rate usually less than 40 beats per minute), AF with complete AV block, or AF with a slow ventricular response. An irregular RR interval identifies AF with a slow ventricular response. If the RR interval is regular, the reader should determine if fibrillatory waves are present to differentiate AF with complete AV block (Fig. 2A) from sinus arrest (Fig. 2B). Occasionally, very fine AF may be difficult to discern from sinus arrest. Increasing the voltage gain setting on the ECG machine and considering the clinical context may be helpful.

Number of P waves more than the number of QRS complexes

If P waves are present, the next step is to determine the relationship between the number of P waves and QRS complexes. If there are more P waves than QRS complexes and the PP interval is regular, the diagnosis is either second-degree AV block or complete AV block. If the non-conducted P wave is premature (i.e. shorter PP interval), the diagnosis is non-conducted atrial ectopic beats (Fig. 2C). To differentiate between various AV blocks, the reader should next check for the regularity of the PR and RR intervals. If the

¹ Department of Cardiology, National University Heart Centre Singapore, Singapore

² Department of Medicine, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

³ Department of Medicine, National University Hospital, National University Health System, Singapore

Correspondence: Dr Ching-Hui Sia, Department of Cardiology, National University Heart Centre Singapore, 1E Kent Ridge Road, NUHS Tower Block Level 9, Singapore 119228.

Email: ching_hui_sia@nuhs.edu.sg

* Joint first authors

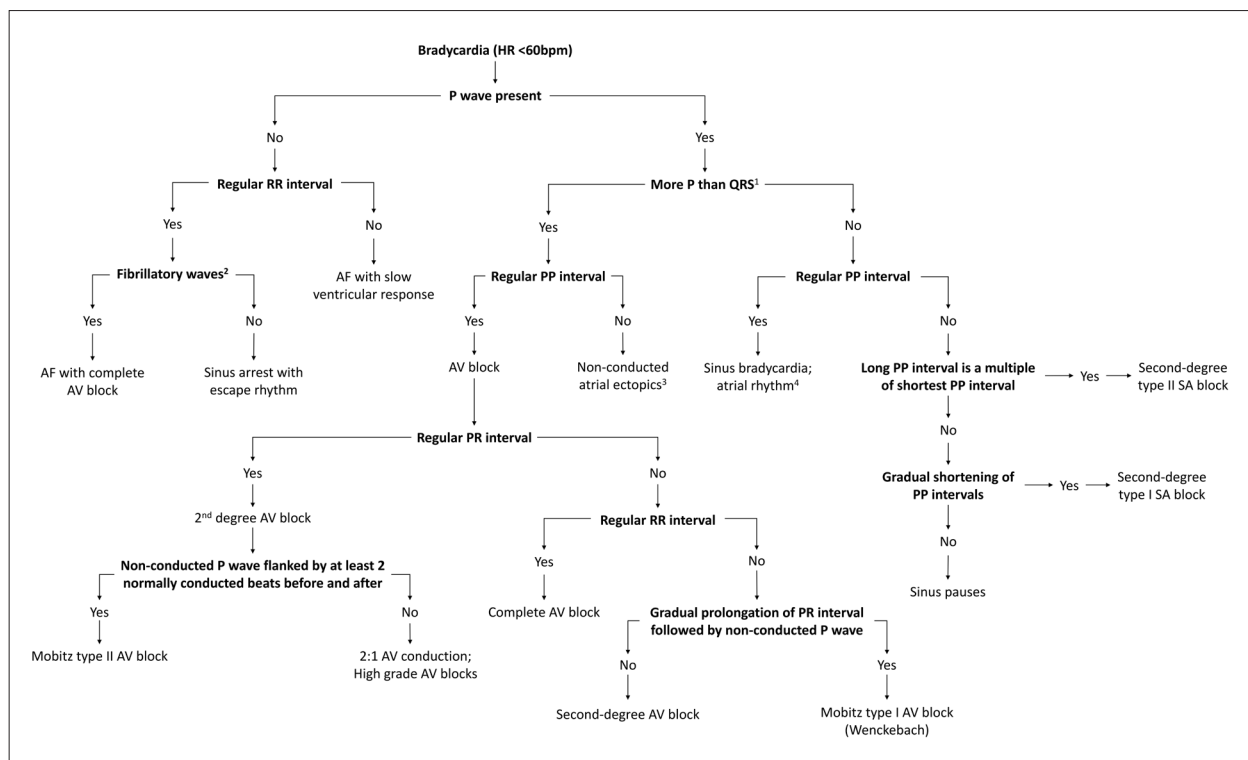


Fig. 1. An algorithmic approach to bradycardia.

AF: atrial fibrillation; AV: atrioventricular; bpm: beats per minute; HR: heart rate; SA: sinoatrial

¹ P waves best identified in inferior leads or lead V1²Fibrillatory waves may not be apparent in fine AF

³ P waves may be buried within the preceding T wave

⁴ Suspect ectopic P wave if P wave axis is abnormal (e.g. inverted P waves in II, III, aVF)

Aids to distinguish supra- versus infra-Hisian site of atrioventricular block

- Markedly prolonged PR interval favours AV nodal site of block
- Broad QRS favours infra-Hisian site of block
- Autonomic manipulation
 - Supra-Hisian blocks improve with exercise/atropine, and worsen with vagal manoeuvres
 - Infra-Hisian blocks improve with vagal manoeuvres, and worsen with exercise/atropine

PR interval is regular, the diagnosis is second-degree AV block i.e. Mobitz type II AV block (Fig. 2D), 2:1 AV block (Fig. 2E), or high-grade AV block (Fig. 2F). Mobitz type II AV block is defined as intermittent non-conducted P waves with constant PR intervals before and after the blocked impulse.² A non-conducted P wave flanked by at least 2 normally conducted beats before and after distinguishes Mobitz type II AV block from the others. A 2:1 AV block involves alternately conducted P waves, while high grade AV blocks include 3:1, 4:1 AV conduction et cetera. QRS complexes may be narrow (supra-Hisian block) or broad (infra-Hisian block).

If the PR interval is irregular, the regularity of the RR interval is considered next. If the RR interval is regular, the diagnosis is complete AV block. Complete AV block is defined by independent atrial and

ventricular activity, which manifests as AV dissociation on the ECG. This is reflected in our algorithm as a combination of regular PP and RR intervals but irregular PR intervals. The QRS width of the escape rhythm may suggest the site of the block (supra-Hisian if QRS complexes are narrow, and infra-Hisian if QRS complexes are broad) (Figs. 2G and 2H). If the RR interval is irregular, the diagnosis is either Mobitz type I AV block (Fig. 2J) or other types of second-degree AV block. Mobitz type I AV block, also known as the Wenckebach phenomenon, is characterised by gradual prolongation of the PR interval followed by a non-conducted P wave. As the increment in PR prolongation decreases with subsequent cycles, there is a progressive shortening of RR intervals prior to the non-conducted P wave. Classically, this manifests as “group beating”.

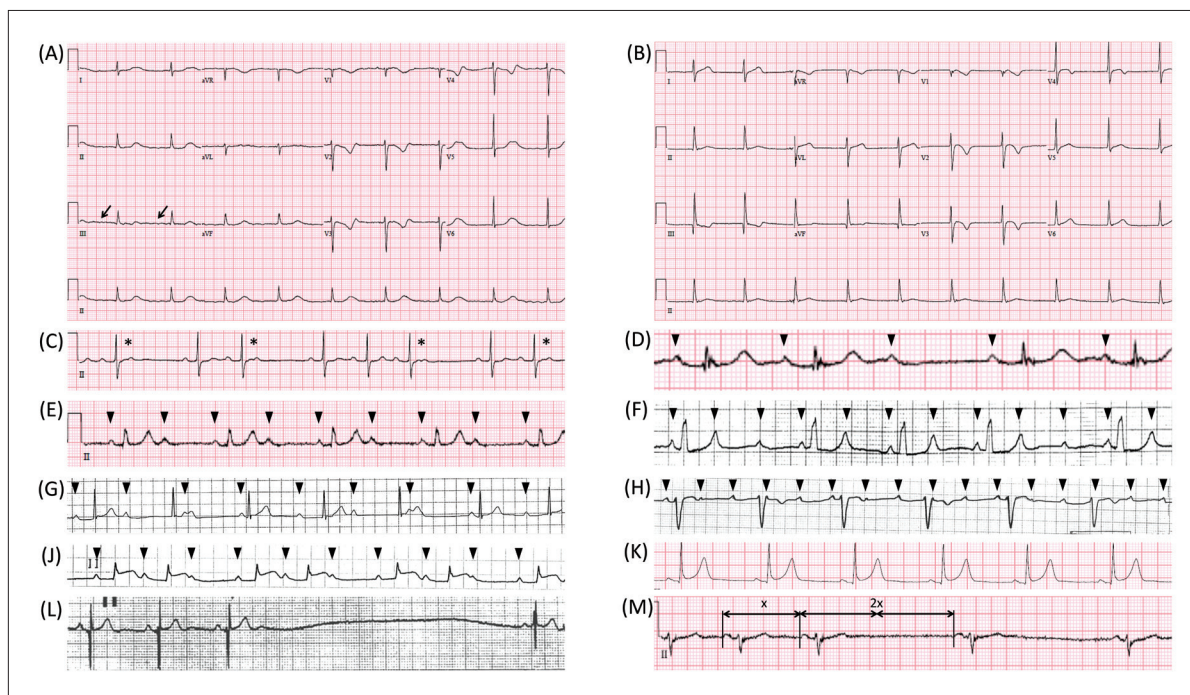


Fig. 2. Application of our algorithm on various electrocardiograms.

(A) Atrial fibrillation (AF) with complete atrioventricular (AV) block (fibrillatory waves in lead III indicated by arrows). (B) Sinus arrest with supraventricular escape rhythm. (C) Sinus rhythm with non-conducted atrial ectopics (indicated by asterisks). (D) Mobitz type II AV block. (E) 2:1 AV block. (F) High-grade AV block. (G and H) Complete AV block. (J) Mobitz type I AV block (P waves indicated by arrowheads). (K) Sinus bradycardia. (L) Sinus pause. (M) Second-degree type II sinoatrial block. The long cycle is twice as long as a short cycle.

Number of P waves not more than the number of QRS complexes

If the number of P waves does not exceed the number of QRS complexes and the PP interval is regular, the diagnosis is often sinus bradycardia (Fig. 2K) or, more rarely, an escape atrial rhythm. Escape atrial rhythms may be identified by an abnormal P wave axis (e.g. a superior axis with negative P waves in leads II, III and aVF), although they may mimic sinus bradycardia if the rhythm originates from atrial tissues close to the sinoatrial (SA) node. If the PP interval is irregular, the diagnosis is either sinus pause (Fig. 2L) or SA block (Fig. 2M). Like AV blocks, SA exit blocks may be classified as first-, second- or third-degree. First-degree SA block occurs when there is a delay between depolarisation of the SA node and the rest of the atrial tissue. Third-degree SA block occurs when no SA nodal impulses are conducted out of the SA node.¹ We did not include first- and third-degree SA blocks in our algorithm as they are not recognisable on the surface ECG. Similar to Mobitz type I AV block, second-degree type I SA block demonstrates the Wenckebach phenomenon, with progressive lengthening of intervals between the SA impulse and atrial depolarisation. This manifests on the surface ECG

as the progressive shortening of the PP interval followed by a sinus pause, and the duration of the sinus pause is less than twice the last PP interval before the pause. Second-degree type II SA block involves intermittent non-conducted SA nodal impulses with constant PP intervals prior to the non-conducted impulse. This condition may be identified by the presence of a mathematical relationship between longer sinus cycles and the shortest sinus cycle (i.e. long cycle duration is a multiple of the shortest cycle duration).

Clinical utility and limitations

ECG reading remains daunting to many, especially medical students and junior doctors, with resultant misinterpretation and inappropriate management decisions.⁶ To the best of our knowledge, our bradycardia algorithm is the first of its kind and may provide both novices and experienced ECG readers with a structured approach to the wide differential diagnosis of bradyarrhythmias. However, as with all decision tools, the correct diagnosis is dependent on careful application of the algorithm, and the reader must be proficient in identifying different components of the ECG—particularly hidden P waves—as well as in assessing the regularity of different time intervals

(PP, PR and RR intervals). Repeated, intentional exposure to ECGs in clinical practice remains essential for honing these pattern recognition skills. Intracardiac electrophysiological recordings may sometimes be required to accurately classify supra- and infra-Hisian blocks. Such detailed site localisation is beyond the scope of our proposed algorithm. To aid the reader, however, we have included footnotes summarising ECG features and simple autonomic manipulation, which may help differentiate supra- and infra-Hisian sites of the block (Fig. 1).

Bradyarrhythmias are common, but there is no structured approach towards their ECG diagnosis. Our novel algorithm may simplify this diagnostic challenge and reduce resultant misdiagnosis and mismanagement.

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