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CASE REPORT: CLINICAL CASE SERIES

Differential Effects of Vagal Activation on the Sinus and Atrioventricular Nodes



Report of 2 Cases

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ABSTRACT

Vagal activation usually affects both sinus and atrioventricular (AV) nodes, manifesting as sinus slowing accompanied by varying degrees of AV block. AV block accompanying sinus acceleration as during treadmill testing is usually considered pathologic. We report 2 cases of vagally mediated reflex AV block accompanied by sinus tachycardia and acceleration. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2020;2:1748-52) © 2020 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/>).

Vagal activation is known to simultaneously affect both the sinus and atrioventricular (AV) nodes. The resulting electrocardiographic (ECG) manifestations can include sinus rate slowing, sinus arrest, and varying degrees of AV node block. One of the characteristic ECG hallmarks of vagally mediated bradycardia is the *simultaneous occurrence of AV block accompanied by sinus slowing*. Therefore, when sinus slowing and AV block occur simultaneously, it is correctly interpreted as reflex

in origin and therefore benign. On the other hand, it is often taught that *AV block that occurs during sinus acceleration* (such as during treadmill exercise testing) should be assumed to be pathologic until proven otherwise, and often leads to consideration of pacemaker implantation.

It may be underappreciated that vagal activation may have disparate effects on the sinus and AV nodes, or may be accompanied by sympathetic co-activation. We report 2 instances of clear vagally mediated AV block, but with concurrent sinus acceleration.

LEARNING OBJECTIVES

- Vagal activation is known to affect both the sinus and AV nodes.
- In some instances, vagal activation may have differing effects on the sinus and AV nodes or may be accompanied by sympathetic co-activation, which results in vagally mediated AV block with concomitant sinus acceleration.

CASE 1

A 46-year-old woman with past medical history of irritable bowel syndrome, obstructive sleep apnea, and moderate obesity presented for upper gastrointestinal endoscopy for gastric polyp removal. Coincident with stomach and duodenal insufflation, she developed a 7-s period of ventricular asystole due to

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AV block. During this period of vagally mediated AV block, her sinus rate was rapid, and *accelerated* to approximately 120 beats/min (Figure 1). With termination of insufflation, normal AV conduction resumed, and her heart rate shortly returned to 75 beats/min. Propofol was discontinued, the procedure was aborted, and she awoke without complications. She had no history of syncope or presyncope. Her physical examination, resting ECG, and echocardiogram were normal. She was discharged with instructions to obtain a sleep study as an outpatient, and to seek immediate medical attention for presyncope or syncope. She has not reported any symptoms since February 2019.

CASE 2

A 61-year-old athletic woman with a structurally normal heart and a normal resting ECG had 2 episodes of syncope with minimal prodrome. Outpatient monitoring revealed rare PVCs that were “short

coupled.” She underwent an electrophysiology study without inducible arrhythmias. An implantable loop recorder was inserted. Outpatient monitoring 14 months after loop implantation identified an 8-s period of asystole (Figure 2) that occurred during an episode of nausea, diaphoresis, retching followed by vomiting and extreme lightheadedness without syncope, typical of a vagal event. Her sinus rate initially remained at approximately 100 beats/min although she developed a prolonged pause punctuated by occasional QRS complexes from an unreliable escape rhythm. Later during the episode, excessive artifact obscures accurate assessment of P waves, but there may have been some sinus rate slowing as the bradycardia progressed.

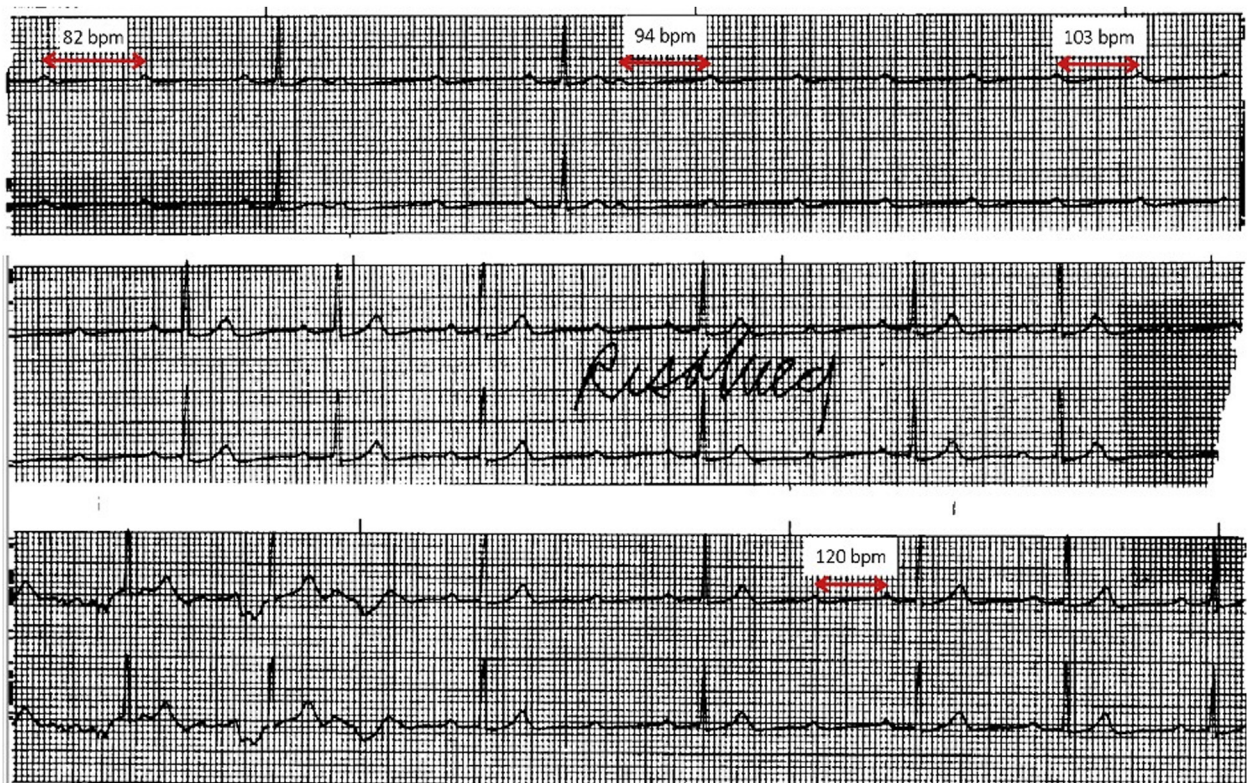
DISCUSSION

In general, AV block that develops during sinus tachycardia or during sinus *acceleration* should be

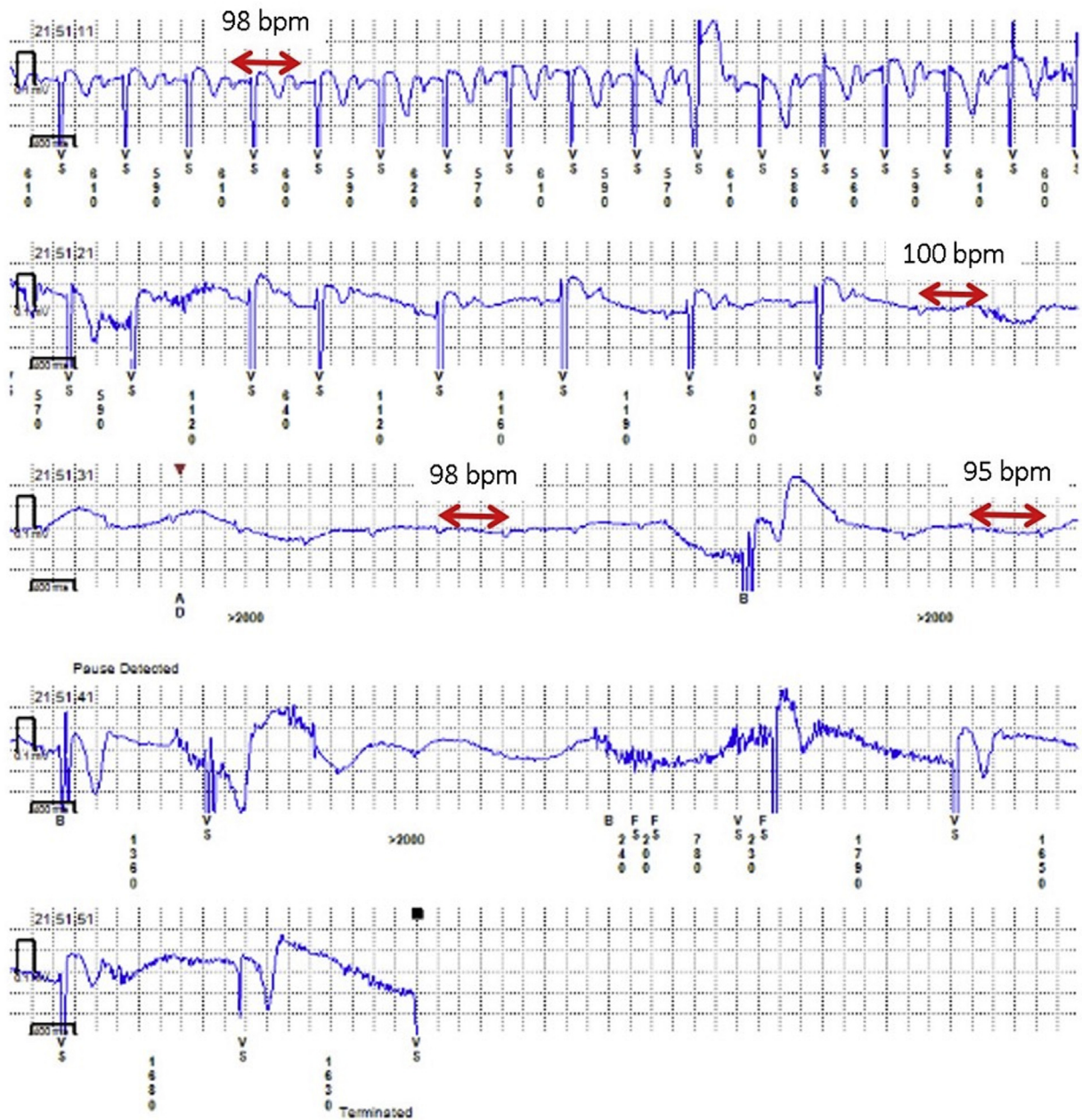
ABBREVIATIONS AND ACRONYMS

AV = atrioventricular
ECG = electrocardiographic

FIGURE 1 Continuous ECG Strip Recorded From Case 1 (See Text for Details)



Sinus acceleration is evident as atrioventricular (AV) block develops, culminating in 6 s of ventricular asystole before AV conduction begins to resume. Even when the sinus rate (indicated by red arrows) has accelerated to 120 beats/min, AV conduction is still not 1:1. ECG, electrocardiogram.

FIGURE 2 Remote Transmission From Case 2 With an Implanted Loop Recorder (See Text for Details)

In the midst of nausea, extreme diaphoresis, retching, and presyncope (all consistent with a vagally mediated syndrome), the sinus rate (indicated by red arrows) remains at approximately 100 beats/min although atrioventricular (AV) node block occurs culminating in significant ventricular asystole. Excessive artifact toward the end of the recording does not allow accurate assessment of sinus cycle length.

considered to be pathologic until proven otherwise. On the other hand, AV block that is preceded or accompanied by sinus *slowing* is most likely to be reflex in origin, mediated by vagal effects on both the sinus and AV node. Such reflex bradycardia (sinus

slowing along with the development of AV block) is commonly seen during a variety of abdominal procedures and extensively described in the literature. We report 2 cases of vagally mediated heart block during rapid sinus rates.

The first case is unusual in that vagal activation during colonic insufflation resulted in AV block during on-going sinus tachycardia without sinus slowing; in fact, the sinus node accelerated, seemingly a “disconnect” between vagal influence on the 2 nodes. The second case showed continued sinus rates of 95 to 100 beats/min for the first many seconds of vagal AV block, although P waves were difficult to assess because of excessive artifact. It is known that sinus node automaticity is more powerfully influenced by vagal inhibition, whereas AV node conduction is largely controlled by sympathetic activation. Therefore, one often sees sinus slowing with continued AV conduction or sinus arrest during vagal activation, but our 2 cases showed the reverse responses. However, it must be acknowledged that vagal activation rarely occurs in isolation, and most often there is an on-going balance between sympathetic and vagal tone.

The gastrointestinal tract is a known source of vagal afferents, and deglutition syncope, especially with cold substances, is a well-described clinical entity. We reviewed 15 published reports of this condition where ECGs during deglutition were available, and none of the ECGs showed sinus acceleration during heart block. Similarly, colonic insufflation during lower endoscopy is also known to cause vagal activation has been reported to occur in 16% of patients (1), resulting in bradycardia due to sinus slowing and/or AV block (2).

The mammalian heart is innervated by post-ganglionic vagal fibers with significant overlap in innervation of both the sinus and AV nodes (3). Typically, vagal stimulation results in sinus node slowing accompanied by slowing of conduction through the AV node. Data describing asymmetry of sympathetic innervation of the heart have been published in the rat model (4). There have been several animal studies exploring the differing effects of the right and left vagal nerves on the activity of the sinus and AV nodes. Stauss (5) studied the effect of left- and right-sided vagal nerve stimulation on the hemodynamics of hypertensive rats. Cervical vagal

nerve stimulation was applied at differing strengths and frequencies, and for different durations; they found that left-sided vagus nerve stimulation produced more pronounced bradycardia than right-sided stimulation. Similarly, Schiereck et al. (6) concluded that left vagal stimulation introduced more heart rate irregularities than right vagus in their study of asynchronous vagal stimulation of rats.

In human volunteers, right carotid baroreflex activation resulted in greater sinus slowing as compared to left-sided activation (7). Furthermore, data confirm that there can be simultaneous activation of the sympathetic and the parasympathetic systems, at least in animal experiments. There have been 2 prior case reports of divergent sinus and AV node responses during vasovagal syncope induced by head-up tilt table testing when sinus tachycardia and AV block coexisted (8,9). Differences in sinus and AV nodal autonomic modulation have also been documented based on the differential behavior of sinus rates and PR intervals during sleep (10).

CONCLUSIONS

These 2 cases highlight paradoxical increase of sinus rate or lack of sinus slowing during vagally mediated AV block. Although uncommon, such divergent behavior highlights differing effects of vagal activation on the sinus and AV nodes, or possibly co-activation of sympathetic and parasympathetic systems. These cases negate the conventional clinical teaching that AV block during sinus tachycardia is always pathologic and an indication for pacemaker implantation. Although usually true, reflex AV block in the setting of sinus acceleration is not *always* pathologic.

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REFERENCES

1. Herman LL, Kurtz RC, McKee KJ, Sun M, Thaler HT, Winawer SJ. Risk factors associated with vasovagal reactions during colonoscopy. *Gastrointest Endoscop* 1993;39:388-91.
2. George AT, Davis C, Rangaraj A, et al. Cardiac ischaemia and rhythm disturbances during elective colonoscopy. *Frontline Gastroenterol* 2010;1:131-7.
3. Martin P. The influence of the parasympathetic nervous system on atrioventricular conduction. *Circ Res* 1977;41:593-9.
4. Xavier CH, Beig MI, Ianzer D, Fontes MAP, Nalivaiko E. Asymmetry in the control of cardiac performance by dorsomedial hypothalamus. *Am J Physiol Regul Integr Comp Physiol* 2013;304:R664-74.
5. Stauss HM. Differential hemodynamic and respiratory responses to right and left cervical vagal nerve stimulation in rats. *Physiol Rep* 2017;5:e13244.
6. Schiereck P, Sanna N, Mosterd WL. AV blocking due to asynchronous vagal stimulation in rats. *Am J Physiol Heart Circ Physiol* 2000;278:H67-73.

7. Tafil-Klawe M, Raschke F, Hildebrandt G. Functional asymmetry in carotid sinus cardiac reflexes in humans. *Eur J Appl Physiol* 1990;60:402-5.

8. Sra J, Singh B, Blanck Z, Dhala A, Akhtar M. Sinus tachycardia with atrioventricular block: an unusual presentation during neurocardiogenic (vasovagal) syncope. *J Cardiovasc Electrophysiol* 1998;9:203-7.

9. Paravolidakis KE, Apostolou TS, Theodorakis GN, Vartela VG, Kremastinos DTh. Accelerated sinus rhythm with high grade A-V block during head-up tilt testing. *EP Europace* 2006;8:128.

10. Mendoza IJ, Castellanos A, Lopera G, Moleiro F, Interian A, Myerburg RJ. Nighttime differential autonomic modulation of sinus and

idioventricular automaticity and of atrioventricular nodal conduction. *Ann Noninvasive Electrocardiol* 1999;4:385-90.

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