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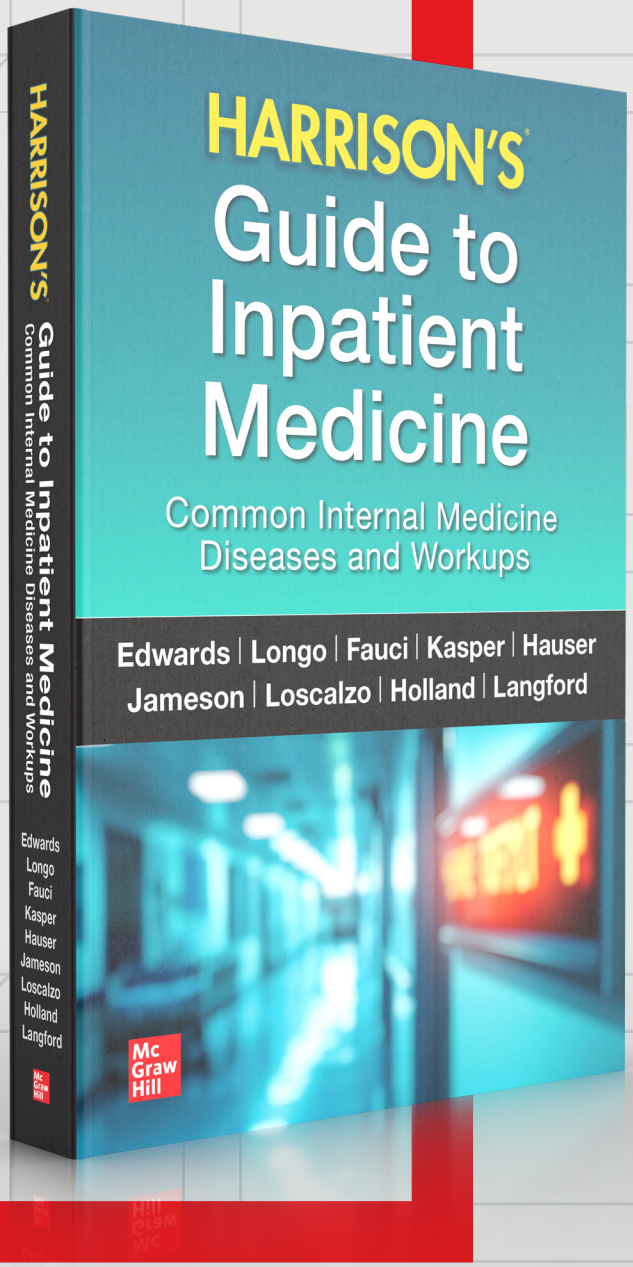
Sample Chapter

Chapter 2:
Bradycardia



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2 Bradycardia

KEY POINTS

1. Bradycardia is a reduced heart rate <60 beats/min. Bradycardia can be categorized into sinus bradycardia or electrical abnormalities originating at the sinoatrial (SA) node or the atrioventricular (AV) node.
2. Patients with bradycardia can be asymptomatic; may experience mild symptoms of palpitations and fatigue; or may have chest pain, dyspnea, dizziness, or signs of end-organ damage. Acute bradycardia is more worrisome than chronic; therefore, a thorough history of the duration of the patient's symptoms is necessary. A focused exam should assess for clues to the bradycardia, including a thorough volume, cardiac, respiratory, and skin exam. While palpation of the radial artery and auscultation of the heart can establish whether the rhythm is regular or irregular, all patients should receive an ECG to determine the specific rhythm.
3. In older adults, sinus bradycardia occurring at rest or with sleep is common. Additionally, older adults commonly have dysfunction of either or both of the SA and AV nodes. In all patients, a thorough medication review should be performed, as iatrogenic bradycardia is common.
4. Bradycardia of any cause resulting in end-organ damage should be managed immediately. Irregular conduction deficits that need urgent evaluation (e.g., pacemaker insertion) include prolonged sinus arrest, second-degree type II AV block, and third-degree AV block.
5. Vital signs and ABCs should be assessed immediately in case life-threatening end-organ damage is present. All patients should receive an ECG and continuous telemetry monitoring. While diagnostic studies should be considered, IV atropine 1 mg is emergently necessary in patients with unstable bradycardia. Transcutaneous and/or transvenous pacing may be necessary in patients not responsive to atropine.

CLINICAL VIGNETTE

An 88-year-old woman with hypertension, HF with reduced ejection fraction, type 2 diabetes mellitus, and CAD was admitted to the general medical floor 2 days ago with an HF exacerbation due to running out of her furosemide for 2 weeks. Her goal-directed medical therapy was resumed upon admission, and IV furosemide twice a day has provided appropriate diuresis. You are paged in the middle of the night and informed by the bedside nurse that the patient's heart rate is 42 beats/min. Upon arrival in the room, the patient is asleep, resting comfortably, and breathing normally. The BP is 122/84 mm Hg and the Spo_2 is 96% on room air. There is 1+ edema of the bilateral lower extremities with some wrinkling noted, the radial pulse is regular, and she has no crackles in the lung fields. Neurologic exam reveals she is alert and oriented upon awakening. On chart review, you note the patient's heart rate during the day ranged from 60 to 70 beats/min. Electrolytes from this morning revealed a potassium of 3.6 mEq/L and magnesium of 1.6 mEq/L.

GUIDING QUESTIONS

1. Does this patient have hemodynamically unstable or stable bradycardia?
2. Besides an ECG, would you order any other diagnostic studies? If so, what would you order?
3. What else would you want to know about this patient?
4. How would you manage this patient?

INTRODUCTION

Sinus bradycardia is a cardiac rhythm with appropriate cardiac muscular depolarization initiating from the sinoatrial (SA) node with a rate of <60 beats/min. Most patients are asymptomatic, while others present with fatigue, lightheadedness, dizziness, exercise intolerance, presyncope or syncope, worsening HF, or cognitive slowing. **SA node dysfunction** is the inability of the SA node to produce an adequate heart rate that meets the physiologic needs of an individual. **Atrioventricular (AV) node dysfunction** represents a delay or disturbance in the transmission of an impulse from the atria to the ventricles and can be due to an anatomic or functional impairment in the heart's conduction system.

DIFFERENTIAL DIAGNOSIS

- Bradycardia can be separated into sinoatrial (SA) node dysfunction or atrioventricular (AV) node dysfunction
- SA node dysfunction, also known as sick sinus syndrome, is diagnosed when the ECG reveals sinus bradycardia, sinus pauses >3 s or sinus arrest, or exit block (such as sinus arrest followed by a junctional beat or a premature atrial contraction)
  - Always evaluate for reversible causes of SA node dysfunction (Table 2-1)

TABLE 2-1 Reversible Causes of Sinus Node Dysfunction

Medical Conditions Associated with Sinus Bradycardia
• Hypothyroidism
• Sleep apnea
• Hypoxia
• Hypothermia
• Increased intracranial pressure
• Lyme disease
• Myocarditis
• COVID-19
• Vagal reflex (cough, pain, etc.)
Medications Associated with Sinus Node Dysfunction
Antihypertensive Medications
• β-Adrenergic receptor blockers
• Clonidine
• Methyldopa
• Nondihydropyridine calcium channel blockers
Antiarrhythmic Medications
• Amiodarone
• Dronedarone
• Flecainide
• Procainamide
• Propafenone
• Quinidine
• Sotalol
• Ivabradine
Psychiatric Medications
• Donepezil
• Lithium
• Opioid analgesics
• Phenothiazine antiemetics and antipsychotics
• Phenytoin
• Selective serotonin reuptake inhibitors
• Tricyclic antidepressants
Other
• Anesthetic drugs (propofol)
• Cannabis
• Digoxin
• Muscle relaxants

Used with permission from Sauer WH, Koplan BA. The bradyarrhythmias: Disorders of the sinoatrial node, in *Harrison's Principles of Internal Medicine,* 22nd ed, D Longo et al (eds). New York, McGraw Hill, 2025.

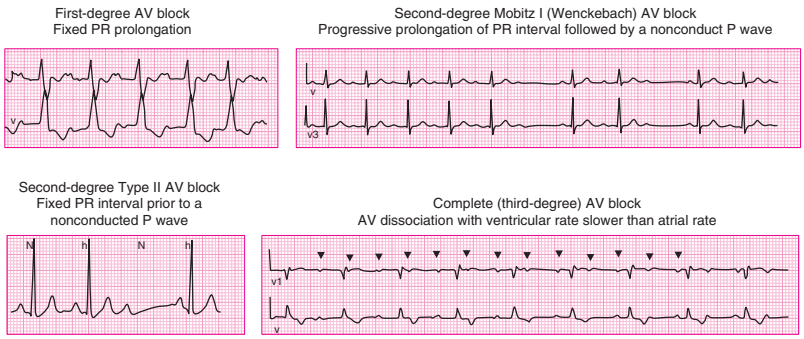

FIGURE 2-1 Types of atrioventricular (AV) block. The *upper left* figure displays fixed prolongation of the PR interval. The *upper right* figure demonstrates Mobitz I block (Wenckebach AV block) manifested as progressive prolongation of the PR interval followed by a nonconducted P wave ("dropped beat"). The *lower left* figure displays AV block with P wave with no QRS complex and no associated PR prolongation prior to the dropped beat (Mobitz type II AV block). The *lower right* figure demonstrates complete heart block manifested as dissociation between P waves and QRS complexes (AV dissociation). (Used with permission from Sauer WH, Koplan BA. The bradyarrhythmias: Disorders of the atrioventricular node, in *Harrison's Principles of Internal Medicine*, 22nd ed, D Longo et al (eds). McGraw Hill, 2025.)

- AV node dysfunction is diagnosed on ECG with bradycardia associated with first-, second-, or third-degree block (Fig. 2-1)
  - Always evaluate for and treat potential underlying etiologies of AV node dysfunction (Table 2-2)

WHAT NOT TO MISS

- Symptomatic and/or hemodynamically unstable bradycardia (especially from MI)
- Second-degree type II AV block
- Third-degree AV block
- Bradycardia of any kind leading to hemodynamic instability or worsening HF

FOCUSED HISTORY

- Always evaluate a patient with bradycardia while obtaining an ECG
- *Determine whether the patient is hemodynamically stable or unstable*
  - Hemodynamically unstable patients with bradycardia have
    - Hypotension
    - Dyspnea, including hypoxia
    - Chest pain suggestive of myocardial ischemia
    - Encephalopathy
    - Acute HF
  - If the patient is hemodynamically unstable, *prepare to give IV atropine 1 mg*
- *Patients with chest pain, dyspnea, altered mental status, and/or hypotension need to be seen urgently*

QUESTIONS AT THE BESIDE

- What are the vital signs?
- Any chest pain or dyspnea?
- Is the patient confused more than their normal?
- Why was the patient admitted?
- Review all medications: any new medications? Any recent dose changes in medications?
- Is telemetry available (if so, review telemetry)?
- Quickly examine the patient and review the chart while waiting for the ECG

TABLE 2-2 Etiologies of Atrioventricular Block

SYSTEM/CATEGORY	CAUSE OF AV BLOCK
Autonomic	Carotid sinus hypersensitivity
	Vasovagal
Metabolic/endocrine	Hyperkalemia
	Hypermagnesemia
	Hypothyroidism
	Adrenal insufficiency
Drug-related	β blockers
	Calcium channel blockers
	Digitalis
	Adenosine
	Antiarrhythmics (class I and III)
	Lithium
Infectious	Endocarditis
	Lyme disease
	Chagas' disease
	Syphilis
	Tuberculosis
	Diphtheria
	Toxoplasmosis
Heritable/congenital	Congenital heart disease
	Maternal SLE
	Kearns-Sayre syndrome
	Myotonic dystrophy and other muscular dystrophies
Inflammatory	SLE
	Rheumatoid arthritis
	Mixed connective tissue disease
	Systemic sclerosis
Infiltrative	Amyloidosis
	Sarcoidosis
	Hemochromatosis
Neoplastic/traumatic	Lymphoma
	Mesothelioma
	Melanoma
	Radiation
	Catheter ablation
Degenerative	Lev's disease
	Lenègre's disease
CAD	Acute MI

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FOCUSED EXAM

- Assess for findings of hypothyroidism, sleep apnea, Lyme disease, SLE, rheumatoid arthritis, systemic sclerosis, amyloidosis, hemochromatosis, and sarcoidosis

GENERAL
- Does the patient look distressed or ill?

VITALS
- Repeat now

HEENT
- Examine for signs of elevated intracranial pressure (e.g., papilledema)

CARDIOVASCULAR
- Heart rate and rhythm (palpate radial artery), jugular venous pressure assessment
- Skin temperature and color
- Capillary refill

RESPIRATORY
- Listen for crackles and breath sounds on both sides

NEUROLOGIC
- Evaluate for confusion or change in level of consciousness

SKIN
- Evaluate for skin rashes or lesions

DIAGNOSTIC TESTS

- ECG and telemetry monitoring
- Consider the following for every patient
  - Troponin
  - BNP
  - CBC
  - Electrolytes
  - Lactic acid
  - TSH
  - CXR
  - Transthoracic echocardiogram
- Other studies are ordered based on what is diagnosed on ECG, and what underlying etiology could cause the diagnosis
  - For example, order an enzyme immunoassay for a patient with third-degree atrioventricular block in whom Lyme disease is suspected
- For aid in interpreting ECGs, see Chap. 53

MANAGEMENT

- Observe patients with sinus bradycardia or sinoatrial (SA) node dysfunction without symptoms
- If feasible, withdraw any medications that could contribute to the bradycardia
- Manage hypokalemia, hyperkalemia, hypomagnesemia, and hypercalcemia, if present
- *Hemodynamically unstable bradycardia*
  - Defined as hypotension, acute altered mental status, ischemic chest discomfort, or acute HF
  - Administer *atropine 1 mg*; can administer every 3–5 min up to 3 mg
  - If atropine is ineffective
    - Prepare for transcutaneous pacing and/or
    - Administer dopamine (5–20 µg/kg per min) or epinephrine (2–10 µg/min)
  - Consult cardiology for management recommendations, including potential need for transvenous pacing and a permanent pacemaker
- Always treat the underlying etiology
- Management of SA node dysfunction that is hemodynamically stable depends on the cause (Fig. 2-2)
- Management of AV node dysfunction that is hemodynamically stable depends on the rhythm and its cause (Fig. 2-3)

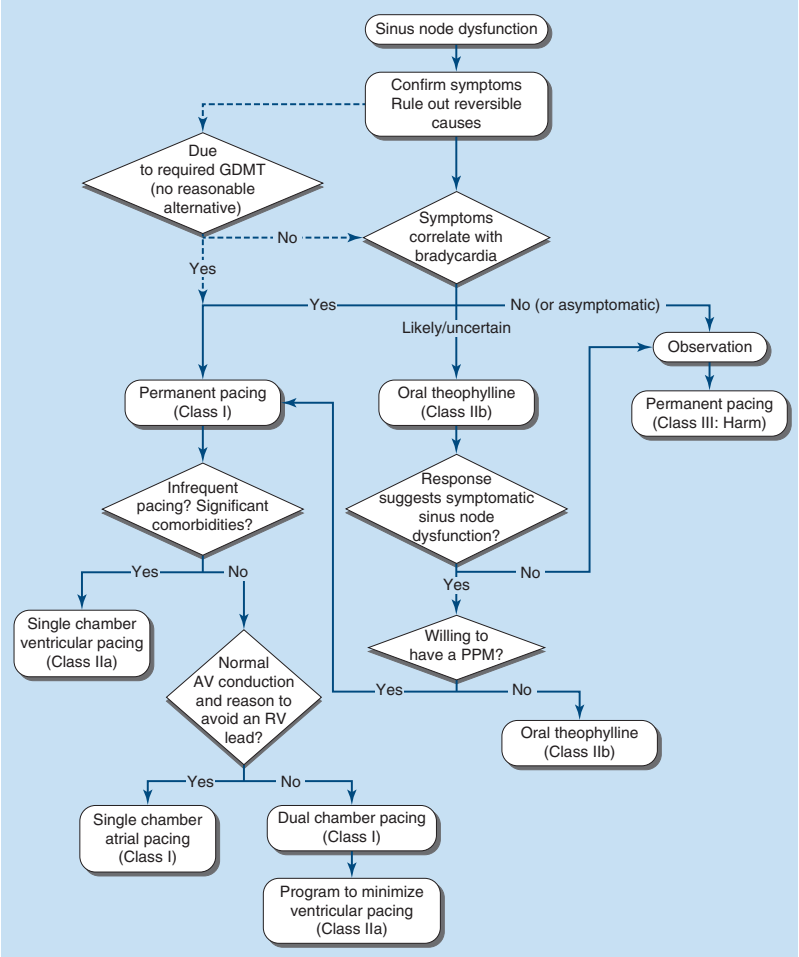

FIGURE 2-2 Management of sinus node dysfunction. Management of sinus node dysfunction begins with eliminating reversible causes and confirming whether symptoms correlate with bradycardia. If symptoms are clearly correlated, permanent pacing should be offered. If it is unclear, a trial of oral theophylline can be considered diagnostically. If there is no correlation between symptoms and bradycardia, then observation is appropriate. Class I recommendations should be performed or are indicated. Class IIa recommendations are considered reasonable to perform. Class IIb recommendations may be considered. Class III recommendations are associated with harm more than benefit. AV, atrioventricular; GDMT, guideline-directed management and therapy; PPM, permanent pacemaker; RV, right ventricular. (Reproduced with permission from FM Kusumoto et al. 2018 ACC/AHA/HRS guideline on the evaluation and management of patients with bradycardia and cardiac conduction delay. Heart Rhythm 16:e128, 2019 and from Sauer WH, Koplan BA. The bradyarrhythmias: Disorders of the sinoatrial node, in *Harrison's Principles of Internal Medicine,* 22nd ed, D Longo et al (eds). McGraw Hill, 2025.)

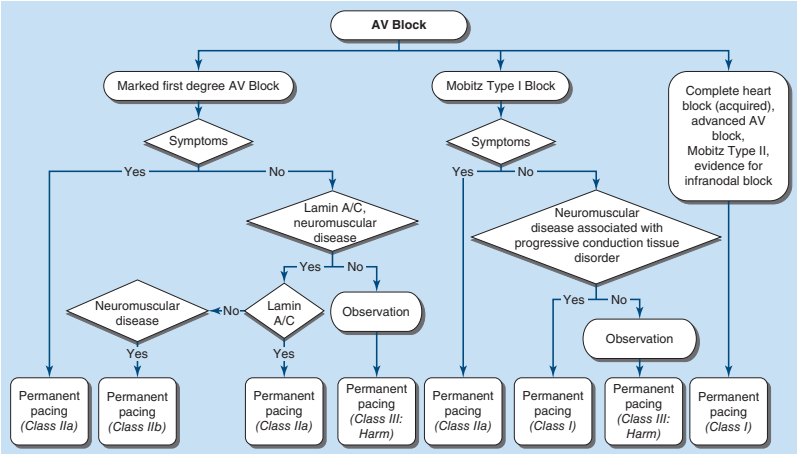

FIGURE 2-3 Indications for pacing in patients with atrioventricular (AV) block. In patients presenting with AV block, the category of AV block should be determined (first-degree, second-degree, or complete heart block). In first-degree AV block, permanent pacing may be indicated in the setting of symptoms or higher-risk systemic disease such as neuromuscular disease or Lamin A/C cardiomyopathy. In Mobitz I AV block, pacing may be considered in the setting of symptoms or the additional disease mentioned with first-degree AV block. In complete heart block or Mobitz II AV block, permanent pacing is generally indicated. Class I recommendations should be performed or are indicated. Class IIa recommendations are considered reasonable to perform. Class IIb recommendations may be considered. Class III recommendations are associated with harm more than benefit. (Reproduced with permission from FM Kusumoto et al. 2018 ACC/AHA/HRS guideline on the evaluation and management of patients with bradycardia and cardiac conduction delay. Heart Rhythm 16:e128, 2019 and from Sauer WH, Koplan BA. The bradyarrhythmias: Disorders of the sinoatrial node, in *Harrison's Principles of Internal Medicine*, 22nd ed, D Longo et al (eds). McGraw Hill, 2025.)

CASE ANSWERS

1. This patient has hemodynamically stable bradycardia. Beside the bradycardia, the other vital signs are normal, and there are no symptoms of end-organ damage to suggest hemodynamically unstable bradycardia.
2. While many diagnostic studies could be ordered, this patient is resting comfortably without signs of end-organ damage. The active management plan includes twice daily IV diuresis, and therefore, serum electrolytes (potassium and magnesium) can be investigated to ensure the levels are adequate in optimizing the cardiac function.
3. This patient with HF with reduced ejection fraction is likely taking a β blocker, which can cause bradycardia. A more thorough review should assess the patient's medications for causes of iatrogenic bradycardia.
4. Older patients taking medications that can cause bradycardia commonly have asymptomatic bradycardia during sleep. As the heart rate was normal during the day, it would be appropriate to observe closely while optimizing serum electrolytes.

FURTHER READING

- Sauer WH et al. Principles of clinical cardiac electrophysiology, in *Harrison's Principles of Internal Medicine*, 22nd ed, D Longo et al (eds). New York, McGraw Hill, 2025.
- Sauer WH, Koplan BA. The bradyarrhythmias: Disorders of the atrioventricular node, in *Harrison's Principles of Internal Medicine*, 22nd ed, D Longo et al (eds). New York, McGraw Hill, 2025.
- Sauer WH, Koplan BA. The bradyarrhythmias: Disorders of the sinoatrial node, in *Harrison's Principles of Internal Medicine*, 22nd ed, D Longo et al (eds). New York, McGraw Hill, 2025.