Evaluation, Workup, and Management of Bradycardia

Bradycardia in the hospitalized patient can indicate underlying conditions ranging from benign physiologic responses to life-threatening cardiac emergencies. This pamphlet provides students with a guide to evaluate, diagnose, and manage bradycardia in the hospital setting, with clinical scenarios to apply the knowledge.

Clinical Presentation

• Definition of Bradycardia:

- Heart rate (HR) <60 bpm in adults (at rest).
- **Severe bradycardia:** HR <40 bpm (often symptomatic, requires urgent evaluation).

• Symptoms:

- **General:** Fatigue, dizziness, lightheadedness, syncope, confusion, exercise intolerance.
- **Cardiac:** Chest pain (if ischemic cause, e.g., MI), dyspnea, heart failure (if low cardiac output).
- **Neurologic:** Altered mental status, syncope (if cerebral hypoperfusion).
- **Hypothyroid:** Cold intolerance, weight gain, dry skin (if bradycardia from hypothyroidism).

• Vital Signs/Exams:

- **HR:** <60 bpm; regular (sinus bradycardia, AV block) vs. irregular (AF with slow ventricular response).
- **BP:** Hypotension (SBP <90 mmHg, if low cardiac output), hypertension (vagal tone, e.g., in athletes).
- **RR:** Normal or tachypnea (if hypoxic or heart failure).
- **Temp:** Hypothermia (hypothyroidism, environmental exposure), fever (if infection-related).
- **Skin:** Cool/clammy (hypoperfusion, shock), dry (hypothyroidism).
- **Neck:** JVD (heart failure, inferior MI with RV involvement), cannon A waves (AV dissociation in complete heart block).
- **Heart:** S3/S4 (heart failure), murmurs (valvular disease, e.g., aortic stenosis), irregular rhythm (AF with slow response).

- **Neuro:** Delayed reflexes (hypothyroidism), focal deficits (if stroke from hypoperfusion).

Differential Diagnosis

• Sinus Bradycardia:

- **Definition:** Normal sinus rhythm with HR <60 bpm, often physiologic or secondary to an underlying cause.
  - **Causes:**
    - **Physiologic:** Common in athletes (increased vagal tone), during sleep, or in healthy individuals (HR 40-60 bpm at rest); usually asymptomatic unless HR <40 bpm.
    - **Hypothyroidism:** Decreased metabolic rate and sympathetic tone lead to bradycardia (HR 40-50 bpm); associated with fatigue, cold intolerance, dry skin, and delayed reflexes.
    - **Medications:**
      - **Beta-Blockers:** Metoprolol, atenolol (block beta-adrenergic receptors, reduce HR).
      - **Non-Dihydropyridine CCBs:** Diltiazem, verapamil (slow AV node conduction).
      - **Digoxin:** Used in AF/heart failure, slows AV node conduction (HR 40-50 bpm, toxic levels >2 ng/mL).
      - **Antiarrhythmics:** Amiodarone, sotalol (prolong repolarization, slow HR).
      - **Opioids:** Morphine, fentanyl (increase vagal tone via mu-opioid receptors).
      - **Clonidine:** Alpha-2 agonist, reduces sympathetic outflow, increases vagal tone.
      - **Electrolyte Imbalances:**
        - **Hyperkalemia:** Elevated K+ (>5.5 mEq/L) slows SA node firing, causes peaked T waves, widened QRS, and eventual sinus arrest.
        - **Hypokalemia:** Less common, but severe hypoK (<2.5 mEq/L) can cause bradycardia via altered repolarization.
        - **Hypomagnesemia:** Mg <1.5 mEq/L can exacerbate drug-induced bradycardia (e.g., digoxin).
    - **Hypothermia:** Core temp <35°C (e.g., environmental exposure, sepsis) slows SA node firing; EKG may show Osborn (J) waves.
    - **Hypoxia:** Severe hypoxia (SpO2 <80%) from pneumonia, PE, or COPD exacerbation can depress SA node function.

        - **Infections:**
            - **Endocarditis:** Bradycardia from AV node involvement (e.g., aortic root abscess), often with fever, new murmur, and embolic phenomena.
            - **Sepsis:** Late-stage sepsis can cause bradycardia (relative bradycardia despite fever), especially in elderly or hypothermic patients.
        - **Increased Vagal Tone:**
            - **Vasovagal Response:** Pain, nausea, or vomiting (e.g., GI bleed, biliary colic) stimulates vagus nerve, causing transient bradycardia (HR 40-50 bpm), often with hypotension.
            - **Carotid Sinus Hypersensitivity:** Neck pressure (e.g., tight collar, shaving) causes reflex bradycardia or asystole (>3 sec pause).
            - **Situational:** Coughing, micturition, defecation increase vagal tone, leading to transient bradycardia.
        - **Neurologic Causes:**
            - **Increased Intracranial Pressure (ICP):** Cushing's triad (bradycardia, hypertension, irregular respirations) from brain injury, hemorrhage, or mass effect.
            - **Neurogenic:** Spinal cord injury (e.g., cervical) can disrupt sympathetic tone, causing unopposed vagal activity and bradycardia.
    - **Other Causes:**
        - **Acute Coronary Syndrome (ACS):** Inferior MI (RCA occlusion) causes SA/AV node ischemia, leading to bradycardia (HR 40-50 bpm), often with AV block.
        - **Obstructive Sleep Apnea:** Hypoxia and vagal stimulation during apneic episodes cause bradycardia (HR 40-50 bpm), especially at night.
        - **Infiltrative Diseases:** Amyloidosis, sarcoidosis, or hemochromatosis can infiltrate the SA node, causing bradycardia or sick sinus syndrome.
- **Features:** Regular rhythm, HR 40-60 bpm, P waves before each QRS, resolves with treatment of underlying cause.

• Atrioventricular (AV) Block:

- **First-Degree AV Block:** PR interval >200 ms; usually benign, no treatment needed unless symptomatic.
- **Second-Degree AV Block:**

- **Mobitz I (Wenckebach):** Progressive PR prolongation, dropped QRS; often vagal (e.g., inferior MI, digoxin toxicity).
- **Mobitz II:** Constant PR, intermittent dropped QRS; higher risk of progression to complete heart block.
- **Third-Degree (Complete) AV Block:** No AV conduction, P waves and QRS independent; escape rhythm (junctional 40-60 bpm, ventricular 20-40 bpm); high risk of asystole.
    - **Causes:** Inferior MI (RCA, Mobitz I), anterior MI (LAD, Mobitz II/III), Lyme disease (AV node inflammation), medications (beta-blockers, digoxin), congenital (e.g., maternal lupus).

• Sick Sinus Syndrome (SSS):

- **Causes:** Idiopathic (aging), ischemic heart disease, infiltrative diseases (amyloidosis, sarcoidosis), medications (beta-blockers, CCBs).
- **Features:** Sinus pauses (>3 sec), sinus arrest, inappropriate sinus bradycardia (HR <50 bpm), alternating bradycardia and tachycardia (tachy-brady syndrome).

• Atrial Fibrillation (AF) with Slow Ventricular Response:

- **Causes:** Overmedication (beta-blockers, digoxin, diltiazem), hypothyroidism, sick sinus syndrome, AV node disease.
- **Features:** Irregularly irregular rhythm, HR <60 bpm, no P waves, variable QRS morphology.

• Junctional Rhythm:

- **Causes:** Digoxin toxicity, inferior MI, SA node dysfunction, post-cardiac surgery.
- **Features:** Regular rhythm, HR 40-60 bpm, absent or retrograde P waves (after QRS), narrow QRS.

• Other Causes:

- **Hypothermia:** Environmental exposure or late sepsis; bradycardia (HR 30-40 bpm) with Osborn waves on EKG.
- **Hyperkalemia:** Severe (K >6.5 mEq/L) causes sinus arrest, junctional rhythm, or asystole.
- **Myocarditis:** Viral (e.g., coxsackievirus) or autoimmune (e.g., lupus), can cause AV block or sinus node dysfunction.

Differential Diagnosis Table

Category	Condition	Key Features	Diagnostic Clues
Physiologic	Sinus Bradycardia	Regular, HR 40-60 bpm, P waves	Common in athletes, resolves with exercise.
Arrhythmic	Second-Degree AV Block	PR prolongation (Mobitz I), dropped QRS	Mobitz II high risk for complete block.
Arrhythmic	Third-Degree AV Block	P waves/QRS independent, HR 20-60 bpm	Escape rhythm, high risk of asystole.
Arrhythmic	Sick Sinus Syndrome	Sinus pauses, tachy-brady syndrome	Often elderly, history of heart disease.

Diagnosis and Labs

• Initial Assessment:

- History: Onset (acute vs. chronic), symptoms (dizziness, syncope), triggers (medications, recent MI), history of thyroid disease, heart disease, or infections (e.g., Lyme).
- Physical Exam: Assess rhythm (regular vs. irregular), volume status (JVD, skin turgor), signs of hypothyroidism (dry skin, delayed reflexes), evidence of heart failure (crackles, JVD), or infection (fever, murmurs).

• Labs:

- Electrolytes:
  - Hyperkalemia (K >5.5 mEq/L, causes sinus arrest), hypokalemia (K <3.0 mEq/L, exacerbates drug effects), hypomagnesemia (Mg <1.5 mEq/L).
- CBC:
  - Anemia (Hgb <10 g/dL, exacerbates ischemia), leukocytosis (infection, e.g., endocarditis).
- Cardiac Biomarkers:
  - **Troponin:** Elevated in MI (NSTEMI/STEMI, >99th percentile), especially inferior MI causing bradycardia.
  - **BNP:** Elevated in heart failure (common with AV block, SSS).
- Thyroid Function Tests:
  - TSH elevated (>5 mIU/L), free T4 low (<0.5 ng/dL) in hypothyroidism.
- Lyme Serology: If AV block and history of tick exposure (positive IgM/IgG).
- Drug Levels:
  - Digoxin (therapeutic 0.5-2.0 ng/mL, toxic >2 ng/mL), beta-blocker toxicity (e.g., metoprolol overdose).

- Blood Cultures:
  - Endocarditis (fever, new murmur, embolic phenomena).

• Imaging/Diagnostic Tests:

- EKG: **First-line to classify bradycardia:**
  - **Sinus Bradycardia:** Regular, P waves before QRS, HR 40-60 bpm.
  - **First-Degree AV Block:** PR >200 ms.
  - **Second-Degree AV Block:** Mobitz I (progressive PR prolongation), Mobitz II (constant PR, dropped QRS).
  - **Third-Degree AV Block:** P waves/QRS independent, escape rhythm.
  - **Junctional Rhythm:** Regular, HR 40-60 bpm, absent/retrograde P waves.
- Echocardiogram:
  - Structural heart disease (cardiomyopathy, valvular disease), wall motion abnormalities (MI), EF (heart failure).
- Chest X-ray:
  - Cardiomegaly (heart failure), infection (pneumonia as a trigger for relative bradycardia in sepsis).
- Holter Monitor:
  - If intermittent symptoms, to capture pauses or AV block.

Diagnostic Workup Table

Test	Indication	Expected Findings	Notes
EKG	Classify Bradycardia	PR >200 ms (AV block), escape rhythm	Urgent if HR <40 bpm, syncope.
Troponin	Inferior MI	>99th percentile (NSTEMI/ STEMI)	Common cause of AV block, bradycardia.
TSH, Free T4	Hypothyroidism	TSH >5 mIU/L, Free T4 <0.5 ng/dL	Associated with fatigue, dry skin.
Echocardiogram	Structural Heart Disease	Low EF, wall motion abnormalities	Urgent if heart failure, new murmur.

Treatment

• General Principles:

- **Stabilize:** ABCs (airway, breathing, circulation), IV access, telemetry, oxygen if SpO2 <90%.
- **Classify rhythm:** Sinus bradycardia vs. AV block vs. junctional rhythm, stable vs. unstable.
- Treat underlying cause (e.g., stop offending drugs, treat hypothyroidism).

• Unstable Bradycardia (Hypotension, Altered Mental Status, Chest Pain, Heart Failure):

- **Atropine:** 0.5 mg IV q3-5min (max 3 mg); increases HR by blocking vagal tone (effective in sinus bradycardia, Mobitz I, junctional rhythm).
- **Transcutaneous Pacing:** If atropine fails or high-degree block (Mobitz II, third-degree); set rate 60-80 bpm, output 2-5 mA above capture threshold.
- **Pressors (Temporary):** Epinephrine 2-10 mcg/min IV or dopamine 2-20 mcg/kg/min IV (titrate to SBP >90 mmHg).
- **Supportive:** IV fluids (NS 500 mL bolus if hypotensive, cautious in heart failure), oxygen, treat underlying cause.

• Stable Bradycardia:

- Sinus Bradycardia:
  - **Treat underlying cause:**
    - **Hypothyroidism:** Levothyroxine 25-50 mcg PO daily (start low, titrate slowly in elderly or cardiac patients).
    - **Medications:** Stop or reduce dose (e.g., beta-blockers, digoxin); if digoxin toxicity, use digoxin immune fab (Digibind) 40-80 mg IV (based on level/ingestion).
    - **Electrolyte Imbalances:**
      - **Hyperkalemia:** Calcium gluconate 1 g IV (stabilizes membrane), insulin 10 units IV + D50 50 mL IV (shifts K into cells), kayexalate 15-30 g PO (removes K).
      - **Hypokalemia/Hypomagnesemia:** Potassium (target K >4 mEq/L), magnesium 1-2 g IV over 1h (target Mg >2 mEq/L).
  - **Hypothermia:** Passive rewarming (warm blankets), IV fluids (NS 500 mL bolus, warmed), treat underlying cause (e.g., antibiotics for sepsis).
  - **Hypoxia:** Oxygen 2-4 L/min, treat underlying cause (e.g., antibiotics for pneumonia, heparin for PE).
  - **Infections:** Antibiotics (e.g., ceftriaxone 2 g IV daily + vancomycin 15 mg/kg IV q12h for endocarditis), source control (e.g., valve surgery).
  - **Increased Vagal Tone:** Address trigger (e.g., pain control with morphine 2-5 mg IV, antiemetics for nausea), monitor for recurrence.
  - **Neurologic Causes:** ICP management (e.g., mannitol 0.5-1 g/kg IV for elevated ICP), neurosurgery consult for mass effect.
- AV Block:
  - **First-Degree/Mobitz I:** Monitor, treat underlying cause (e.g., stop beta-blockers, treat inferior MI).

- **Mobitz II/Third-Degree:** Prepare for transcutaneous pacing (if symptomatic), permanent pacemaker (long-term), treat underlying cause (e.g., antibiotics for Lyme).

- Sick Sinus Syndrome:
- **Monitor:** Telemetry for pauses, tachy-brady episodes.
- **§ Pacemaker:** If symptomatic (syncope, heart failure), permanent pacemaker indicated.
- **§ Treat Cause:** Stop offending drugs, manage ischemia (e.g., PCI for CAD).
- o AF with Slow Ventricular Response:
- **§ Adjust Medications:** Reduce beta-blockers, CCBs, or digoxin; if digoxin toxicity, use digoxin immune fab.
- **§ Pacemaker:** If SSS or AV node disease causing slow rate.

• Underlying Causes:

- **Inferior MI:** Aspirin 325 mg PO, heparin 60 units/kg IV bolus, then 12 units/kg/h infusion, emergent cardiology consult for PCI.
- **Hypothyroidism:** Levothyroxine 25-50 mcg PO daily, monitor TSH q4-6 weeks.
- **Hyperkalemia:** Calcium gluconate 1 g IV, insulin + D50, kayexalate as above.

Overall Evaluation

• Step 1: Assess Stability:

- Unstable (hypotension, altered mental status, chest pain, heart failure): Immediate atropine, pacing, or pressors.
- Stable**:** Proceed with diagnostic workup and targeted therapy.

• Step 2: Classify Rhythm:

- **EKG:** Sinus bradycardia vs. AV block vs. junctional rhythm.
- **Sinus Bradycardia:** Regular, P waves before QRS, HR 40-60 bpm.
- **AV Block:** First-degree (PR >200 ms), second-degree (Mobitz I/II), third-degree (P/QRS dissociation).
- **Junctional:** Regular, HR 40-60 bpm, absent/retrograde P waves.

• Step 3: Diagnostic Workup:

- **Labs:** Electrolytes, troponin, TSH, Lyme serology, digoxin levels, CBC.
- **Imaging:** EKG, echo (structural heart disease), CXR (infection, heart failure).
- **Monitor:** Telemetry, frequent vitals, response to therapy.

• Step 4: Treat and Monitor:

- **Unstable:** Atropine, pacing, supportive care (fluids, pressors).
- **Stable:** Treat underlying cause (e.g., stop beta-blockers, treat hypothyroidism).
- **Monitor:** HR, BP, symptoms, EKG changes, complications (e.g., heart failure, asystole).

• Step 5: Consult Specialists:

- **Cardiology:** AV block (Mobitz II, third-degree), SSS, inferior MI, need for pacemaker.
- **Endocrinology:** Hypothyroidism.
- **Infectious Disease:** Endocarditis, Lyme disease.

Key Pearls

• **EKG First:** Classify bradycardia within 5 min; third-degree AV block = high risk for asystole.

• **Stability:** Unstable bradycardia (HR <40 bpm, hypotension) requires immediate atropine/pacing; stable allows for workup.

• **Sinus Bradycardia:** Often secondary; treat the cause (e.g., stop beta-blockers, treat hypothyroidism).

• **Atropine:** First-line for unstable sinus bradycardia, Mobitz I, junctional rhythm; ineffective in high-degree AV block.

• **AV Block:** Mobitz II and third-degree often require pacing; inferior MI commonly causes transient AV block.

• **Pacemaker:** Indicated for symptomatic SSS, Mobitz II, third-degree AV block, or tachy-brady syndrome.

• **Consultants:** Urgent for unstable bradycardia, inferior MI, high-degree AV block; routine for hypothyroidism, Lyme workup.

References

• **UpToDate:** “Evaluation and Management of Bradycardia in the Hospitalized Patient” (2025).

• **AHA/ACC:** “Guidelines for the Management of Bradycardia and AV Block” (2023).

• **NEJM:** “Bradycardia: Diagnosis and Treatment” (2024).

• **JACC:** “Sick Sinus Syndrome: A Review” (2024).

Clinical Scenarios

Case 1: A 70-Year-Old Male with Dizziness

- Presentation: A 70-year-old male with HTN, on metoprolol 50 mg BID, presents with dizziness and fatigue for 2 days.
- Exam: BP 100/60 mmHg, HR 38 bpm, no JVD, clear lungs.
- EKG: Sinus bradycardia, HR 38 bpm, regular rhythm, P waves before QRS.
- Labs:: TSH 6.5 mIU/L, free T4 0.4 ng/dL, Cr 1.2 mg/dL.
- Diagnosis: Sinus Bradycardia (Beta-Blocker and Hypothyroidism) → Bradycardia, fatigue, on beta-blocker, elevated TSH.
- Management: Reduce metoprolol to 25 mg BID, monitor HR. Start levothyroxine 25 mcg PO daily. Monitor telemetry for worsening bradycardia. Routine endocrinology consult for hypothyroidism management. Monitor TSH q4-6 weeks, HR, and symptoms.

Case 2: A 55-Year-Old Female with Syncope

- Presentation: A 55-year-old female with recent inferior MI presents with syncope and chest pain for 1 hour. Exam: BP 85/55 mmHg, HR 35 bpm, JVD, cool extremities.
- EKG: Third-degree AV block, HR 35 bpm, P waves/QRS independent, junctional escape rhythm.
- Labs: Troponin 2.0 ng/mL (elevated), K 4.0 mEq/L.
- Diagnosis: Third-Degree AV Block (Inferior MI) → Bradycardia, syncope, hypotension, recent MI, EKG findings.
- Management: Atropine 0.5 mg IV q3-5min (max 3 mg, ineffective in high-degree block). Transcutaneous pacing (set rate 70 bpm). Emergent cardiology consult for temporary pacemaker, PCI (RCA occlusion likely). Aspirin 325 mg PO, heparin 60 units/kg IV bolus, then 12 units/kg/h infusion. Monitor telemetry, BP, and troponin. ICU admission.

Case 3: A 40-Year-Old Male with Fever

- Presentation: A 40-year-old male with a history of tick exposure presents with fever, fatigue, and syncope for 1 day. Exam: BP 110/70 mmHg, HR 45 bpm, new murmur (tricuspid regurgitation), petechiae.

- EKG: Second-degree AV block (Mobitz I), HR 45 bpm, progressive PR prolongation, dropped QRS.
- Labs: Lyme IgM/IgG positive, troponin normal, WBC 12,000/µL.
- Diagnosis: Second-Degree AV Block (Lyme Carditis) → Bradycardia, fever, tick exposure, Mobitz I block, positive Lyme serology.
- Management:
- Ceftriaxone 2 g IV daily (Lyme carditis). Monitor telemetry for progression to third-degree block. Atropine 0.5 mg IV if symptomatic (HR <40 bpm, hypotension). Cardiology consult for potential temporary pacing (if progresses). Infectious disease consult for Lyme management. Monitor HR, EKG, and fever resolution.