

BRADYARRHYTHMIAS

Relevant Guidelines

ACCF/AHA/HRS 2018 guideline on bradycardia and conduction delay

2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay. *J Am Coll Cardiol.* 2019;74:932-987.

ESC 2021 guidelines on pacing and cardiac resynchronization

2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy. *Eur Heart J.* 2021.

ESC 2025 guidelines on pregnancy

ESC 2025 Guidelines on the management of cardiovascular diseases and pregnancy. *Eur Heart J.* 2025

Relevant Scientific Statements and Position Papers

AHA 2020 Scientific Statement on Drug-induced Arrhythmias

Drug-Induced Arrhythmias: A Scientific Statement From the American Heart Association. *Circulation.* 2020

AHA 2021 Scientific Statement on Arrhythmias in Cardio-Oncology

Recognition, Prevention, and Management of Arrhythmias and Autonomic Disorders in Cardio-Oncology: A Scientific Statement From the American Heart Association. *Circulation.* 2021;144:e41-e55

EHRA 2021 expert consensus statement on optimal implantation techniques

EHRA expert consensus statement and practical guide on optimal implantation technique for conventional pacemakers and implantable cardioverter-defibrillators. *Europace* 2021

EHRA/HRS/APHRS/LAHS 2022 Expert Consensus Statement on Genetic Testing

Expert Consensus Statement on the State of Genetic Testing for Cardiac Diseases. *Europace* 2022

HRS/APHRS/LAHS 2023 guideline on physiologic pacing

2023 HRS/APHRS/LAHS guideline on cardiac physiologic pacing for the avoidance and mitigation of heart failure. *Heart Rhythm.* 2023;20:e17-e91.

DISORDERS OF THE CARDIAC CONDUCTION SYSTEM

Anatomy

The **sinus node** is a crescent-like, 2.5 mm long subepicardial structure with irregular margins. It is not insulated by a sheath of fibrous tissue, and there are multiple extensions to the atrial myocardium.¹ There are no histologically specialized conduction tissues between the sinus and AV node, and the sinus impulse is transmitted via several exit pathways which electrically bridge the nodal tissue and atrial myocardium,² and then preferentially toward the AV node via muscle bundles with well aligned arrangement of cardiomyocytes.³ Impulses arrive at the **AV node** that functions as a filter for ventricular protection from fast atrial rates as well as a backup pacemaker in case of sinus node dysfunction.⁴ Conduction to the ventricles is then through the **bundle of His** which passes via the annulus fibrosus and penetrates the membranous intraventricular septum before separating into the left and right bundle branches at the superior margin of the muscular septum. The **right bundle** crosses the anterior part of the intraventricular septum and reaches the apex of the ventricle and the base of the anterior papillary muscle. The **left bundle** emerges from the inferior border of the membranous septum at the base of the interleaflet triangle between the right and noncoronary aortic leaflets, and then divides into **anterior** and **posterior fascicles**, which course towards the anterior and posterior papillary muscles of the left ventricle respectively. The **septal bundle** arises from the anterior/posterior fascicle or the main LBB.^{5,6} Finally, the bundle branches ramify to produce the endocardial **Purkinje fibers** which activate the ventricles. Dense innervation of the sinus node and the conduction system by postganglionic adrenergic and cholinergic nerve terminals determine sinus rate and AV conduction.

The sinus nodal branch of the right coronary artery (sinus nodal branch may also originate from the proximal circumflex artery in up to 40% of cases) provides blood supply to sinus node (Table 1). In 85-90% of human hearts blood supply to the AV node (AV nodal artery) is provided by the distal RCA, and by the left circumflex in the remainder. Septal branches of the LAD also provide blood to the upper muscular interventricular septum and the conduction system. The specialized cells of the cardiac conduction system have relatively poor contractility and express specialized ion channels and gap-junction proteins, such as connexins, that mediate electrical coupling with neighboring cells.

Aetiology

Conduction disorders may be seen in various conditions. Mutations that affect the cardiac conduction system and are associated with specific conduction disturbances are presented in relevant Chapters.⁷ Medications and conditions associated with bradycardia and conduction disorders are presented in

Tables 2 and 3.^{8,9}

General Evaluation of Bradycardia or Conduction Disorders

The term “symptomatic bradycardia” refers to a documented bradyarrhythmia that is directly responsible for development of the clinical manifestations of syncope or presyncope, transient dizziness or lightheadedness, heart failure symptoms, or confusional states resulting from cerebral hypoperfusion attributable to slow heart rate.¹⁰ It is due to sinus nodal disease or atrioventricular block. Classification, causes, and recommendation for the initial assessment of bradyarrhythmias are presented in Tables 4-7 and Figures 1-3.^{10,11}

Acute Therapy of Bradycardia Attributable to Sinus Node Disease or AV Block

Recommendations for bradycardias in general are provided in Tables 8-12 and Figure 4. Specific recommendations for sinus bradycardia and AV block are provided in the relevant Chapters.

References

1. Sanchez-Quintana D, et al. Sinus node revisited in the era of electroanatomical mapping and catheter ablation. *Heart*. 2005;91:189-194. doi: 91/2/189 [pii] 10.1136/hrt.2003.031542
2. Fedorov VV, et al. Optical mapping of the isolated coronary-perfused human sinus node. *J Am Coll Cardiol*. 2010;56:1386-1394. doi: 10.1016/j.jacc.2010.03.098 S0735-1097(10)03457-1 [pii]
3. Ho SY, et al. Atrial structure and fibres: morphologic bases of atrial conduction. *Cardiovascular Research*. 2002;54:325-336. doi: 10.1016/S0008-6363(02)00226-2
4. Kurian T, et al. Anatomy and electrophysiology of the human AV node. *Pacing Clin Electrophysiol*. 2010;33:754-762. doi: 10.1111/j.1540-8159.2010.02699.x PACE2699 [pii]
5. Tan NY, et al. Left Bundle Branch Block: Current and Future Perspectives. *Circ Arrhythm Electrophysiol*. 2020;13:e008239. doi: 10.1161/CIRCEP.119.008239
6. Cabrera JA, et al. The Atrioventricular Conduction Axis and its Implications for Permanent Pacing. *Arrhythm Electrophysiol Rev*. 2021.
7. Wilde AAM, et al. European Heart Rhythm Association (EHRA)/Heart Rhythm Society (HRS)/Asia Pacific Heart Rhythm Society (APHRS)/Latin American Heart Rhythm Society (LAHRS) Expert Consensus Statement on the state of genetic testing for cardiac diseases. *Europace*. 2022. doi: 10.1093/europace/euac030
8. Tisdale JE, et al. Drug-Induced Arrhythmias: A Scientific Statement From the American Heart Association. *Circulation*. 2020;CIR0000000000000905. doi: 10.1161/CIR.0000000000000905
9. Fradley MG, et al. Recognition, Prevention, and Management of Arrhythmias and Autonomic Disorders in Cardio-Oncology: A Scientific Statement From the American Heart Association. *Circulation*. 2021;144:e41-e55. doi: 10.1161/CIR.0000000000000986
10. Kusumoto FM, et al. 2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay. *JACC*. 2018. doi: 10.1016/j.jacc.2018.10.044
11. Glikson M, et al. 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy. *Eur Heart J*. 2021. doi: 10.1093/eurheartj/ehab364

