# 15 - 254 Physiologic and Nonphysiologic Sinus Rhythm

## 254 Physiologic and Nonphysiologic Sinus Rhythm

The most common SVT is sinus tachycardia in response to physi ologic stress, such as exercise, but it can also be a manifestation of acute illness. The first step in diagnosis of SVT is to consider the possibility of sinus tachycardia. Therapy is then determined by the clinical findings and probable diagnosis. If sinus tachycardia is diagnosed, treatment of the underlying inciting cause is the primary approach. If the arrhythmia is ongoing and is not due to sinus tachy cardia, initial assessment determines whether immediate therapy is needed to terminate the arrhythmia or slow the rate. Arrhythmias that cause hypotension, impaired consciousness, angina, or heart failure warrant immediate therapy, guided by the type of arrhythmia. Treat ment options for specific types of SVT are discussed in more detail in subsequent chapters and include pharmacologic and procedural interventions. ■ ■FURTHER READING Brugada J et al: 2019 ESC guidelines for the management of patients with supraventricular tachycardia. The task force for the management of patients with supraventricular tachycardia of the European Society of Cardiology (ESC) developed in collaboration with the Association for European Paediatric and Congenital Cardiology (AEPC). Eur Heart J 41:655, 2020. Callans DJ: Josephson’s Clinical Cardiac Electrophysiology: Techniques and Interpretations, 7th ed. Philadelphia, Wolters Kluwer, 2024. William H. Sauer, Paul C. Zei

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Nonphysiologic Sinus

Rhythm The sinus node is composed of a group of cells located in the lateral superior aspect of the junction between the right atrium and superior vena cava, within the superior aspect of the thick ridge of muscle II, III, aVF SVC Sinus node V1 Compact AVN FO CS Os aVR Eustachian ridge IVC A B FIGURE 254-1 Right atrial anatomy pertinent to normal sinus rhythm and supraventricular tachycardia. A. Typical P-wave morphology during normal sinus rhythm based on standard 12-lead electrocardiogram. There is a positive P wave in leads II, III, and aVF and a biphasic, initially positive P wave in aVR. B. Right atrial anatomy seen from a right lateral perspective with lateral

wall opened to view the septum. AVN, atrioventricular node; CS Os, coronary sinus ostium; FO, fossa ovalis; IVC, inferior vena cava; TVA, tricuspid valve annulus.

known as the crista terminalis where the posterior smooth atrial wall derived from the sinus venosus meets the trabeculated anterior portion of the right atrium. Patients with sinus tachycardia will often seek medical attention with the uncomfortable awareness of their heartbeat as their chief complaint. Often, an arrhythmia is suspected because of the similar constellation of symptoms that accompanies supraventricular and ventricular tachycardia or atrial and ventricular ectopy. However, a careful review of the 12-lead electrocardiogram (ECG) reveals a characteristic P wave originating from the superior and lateral aspect of the right atrium with a positive deflection in leads I, II, and III and a biphasic morphology in lead V1. Sinus P waves are characterized by a frontal plane axis directed inferiorly and leftward, with positive P waves in leads II, III, and aVF; a nega tive P wave in aVR; and an initially positive biphasic P wave in V1. Normal sinus rhythm has a range of rates between 60 and 100 beats/ min (Fig. 254-1).

CHAPTER 254 Physiologic and Nonphysiologic Sinus Rhythm
SINUS ARRHYTHMIA Sinus arrhythmia is a common finding that is usually asymptomatic and related to normal physiology in healthy individuals. The rhythm is defined as arising from a sinus node origin but with irregular ity between P-P intervals of >120 ms. When there is an irregularity in the heart rhythm and there are different P-wave morphologies observed, then this arrhythmia is most likely due to premature atrial contractions (PACs) and not sinus arrhythmia. Sinus arrhythmia usu ally occurs at rest and is often eliminated with higher rates observed with exertion due to removal of vagal tone. The three types of sinus arrhythmias observed are respirophasic, ventriculophasic, and non phasic. Respirophasic sinus arrhythmia occurs when vagal tone is inhibited reflexively during inspiration and is restored with expira tion. A similar phenomenon is seen with breath-holding leading to exaggerated pauses most often seen with obstructive sleep apnea. Ventriculophasic sinus arrhythmia is most often observed with heart block or after a premature ventricular contraction (PVC). The P-P interval is shortened when there is an interposed ventricular complex seen in these conditions possibly related to the triggered baroreceptor reflex from the subsequent beat after a longer ventricular filling time and increased stroke volume. Nonphasic sinus arrhythmia refers to variations in sinus P-P intervals unrelated to the cardiac or respiratory cycle. Regardless of the mechanism, asymptomatic sinus arrhythmia does not warrant further cardiac evaluation and is not considered pathogenic. Crista terminalis Pectinate muscles TVA Triangle of Koch

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B FIGURE 254-2 Outpatient telemetry monitor in a patient with intermittent atrial tachycardia (A) and normal physiologic sinus tachycardia (B). PHYSIOLOGIC SINUS TACHYCARDIA Sinus tachycardia (>100 beats/min) typically occurs in response to sympathetic stimulation and/or vagal withdrawal, whereby the rate of spontaneous depolarization of the sinus node increases and the focus of earliest activation within the node typically shifts more leftward and closer to the superior septal

aspect of the crista terminalis, thus pro ducing taller P waves in the inferior limb leads when compared to nor mal sinus rhythm. Sinus bradycardia is defined as rates <60 beats/min; however, bradycardia can be normal during sleep and in fit individuals. Sinus tachycardia is considered physiologic when it is an appropriate response to exercise, stress, or illness. Sinus tachycardia can be difficult to distinguish from focal atrial tachycardia (see below) that originates near the sinus node. A causative factor (e.g., exertion) and a gradual rate increase favor a diagnosis of sinus tachycardia, whereas abrupt tachycardia onset and offset favor atrial tachycardia (Fig. 254-2). The distinction can be difficult and occasionally requires extended ECG monitoring or invasive electrophysiology study. Treatment for physiologic sinus tachycardia is aimed at the underlying condition, but frequently, no therapy is necessary. Consideration to abnormal thyroid conditions and anemia should be given in patients with sinus tachy cardia as these represent reversible causes. In addition, structural and functional cardiovascular abnormalities can present as sinus tachycar dia, especially pulmonary embolism, and thus must be ruled out in the appropriate clinical scenario before considering sinus tachycardia as nonphysiologic. Finally, as sinus rate varies widely between individu als, a relatively elevated sinus rate (whether at rest or during exercise) without underlying cause, particularly without symptoms, typically does not warrant treatment (Table 254-1). TABLE 254-1 Common Causes of Sinus Tachycardia Physiologic Causes Emotion, physical exercise, sexual intercourse, pain, pregnancy Pathologic Causes Anxiety, panic attack, anemia, fever, dehydration, infection, malignancies, hyperthyroidism, hypoglycemia, pheochromocytoma, Cushing’s disease, diabetes mellitus with evidence of autonomic dysfunction, pulmonary embolus, myocardial infarction, pericarditis, valve disease, decompensated heart failure, shock, alcohol withdrawal Drugs Epinephrine, norepinephrine, dopamine, dobutamine, atropine, β2-adrenergic receptor agonists (salbutamol), methylxanthines, doxorubicin, daunorubicin, beta blocker withdrawal, caffeine, alcohol Illicit Drugs Amphetamines, cocaine, lysergic acid diethylamide, psilocybin, ecstasy, cocaine

NONPHYSIOLOGIC SINUS TACHYCARDIA Inappropriate sinus tachycardia is an uncommon condition in which the sinus rate increases spontaneously at rest or out of proportion to physiologic stress or exertion and is within a spectrum of ill-defined conditions associated with autonomic dysregulation. The underly ing mechanism remains elusive, but it may be related to imbalance between sympathetic and parasympathetic inputs to the sinus node, altered membrane automaticity of sinus node cells, or a combination of both. Affected individuals are often women in the third or fourth decade of life. Fatigue, dizziness, and even syncope may accompany palpitations, which can be disabling. Additional symptoms of chest pain, headaches, and gastrointestinal upset are common. Inappropri ate sinus tachycardia must be distinguished from appropriate sinus tachycardia and from focal atrial tachycardia arising from a region near the sinus node. The distinction between physiologic sinus tachycardia due to an anxiety disorder and inappropriate sinus tachycardia can be difficult. Therapy is often ineffective or poorly tolerated. Careful titra tion of beta blockers may reduce symptoms. Clonidine and serotonin reuptake inhibitors have also been used. Ivabradine, a drug that blocks the If current that causes spontaneous sinus node depolarization, is approved in the United States for use in heart failure but has also been effective in the treatment of inappropriate sinus tachycardia. Catheter ablation of the sinus node to modify and thereby decrease the sinus rate has been performed, but long-term control of symptoms is usu ally poor and can result in a permanent pacemaker requirement due to resultant symptomatic sinus bradycardia or arrest, or chronotropic incompetence (Fig. 254-3). Postural orthostatic tachycardia syndrome (POTS) is characterized by symptomatic sinus tachycardia that occurs with postural change from a supine position to standing. The sinus rate increases by 30 beats/min or to

>120 beats/min within 10 min of standing and in the absence of hypotension. Symptoms are often similar to those in patients with inappropriate sinus tachycardia. POTS is sometimes due to autonomic dysfunction following a viral illness and may resolve spontaneously over 3–12 months. Prolonged postviral symptoms after COVID-19 infection, sometimes referred to as “long COVID,” have been ascribed to autonomic dysfunction and a POTS-like presentation. Volume expansion with salt supplementation, oral fludrocortisone, compres sion stockings, and the α-agonist midodrine, often in combination, can be helpful. Exercise training has also been shown to improve symptoms Sinus tachycardia Identify and treat reversible causes (See Table 254-1) Evaluate for POTS Treatment of POTS • Recumbent exercise and conditioning regimen • High-salt diet • Compression stockings • Fludrocortisone • Midodrine IST suspected Beta blocker and/or ivabradine Consider catheter ablation FIGURE 254-3 Evaluation and treatment of sinus tachycardia. For the patient who presents with sinus tachycardia, reversible causes of appropriate sinus tachycardia must be excluded and treated as indicated. Otherwise, evaluation for a spectrum of syndromes resulting in inappropriate sinus tachycardia should be undertaken. Potential directed therapies are shown. IST, inappropriate sinus tachycardia; POTS, postural orthostatic tachycardia syndrome.

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