Chapter 6: Arrhythmias

INTRODUCTION

- *Cardiac arrhythmia* involves a group of conditions in which the heartbeat is irregular, too slow, or too fast. *Supraventricular arrhythmias* occur above the ventricles, and *ventricular arrhythmias* occur within the ventricles.

PATHOPHYSIOLOGY

Supraventricular Arrhythmias

Atrial Fibrillation and Atrial Flutter

- Atrial fibrillation (AF) has extremely rapid (400–600 atrial beats/min) and disorganized atrial activation. There is loss of atrial contraction (atrial kick), and supraventricular impulses penetrate the atrioventricular (AV) conduction system to variable degrees, resulting in irregular ventricular activation and an irregularly irregular pulse. The AV junction will not conduct most of the supraventricular impulses, causing the ventricular response to be considerably slower than the atrial rate.
- Atrial flutter has rapid (270–330 atrial beats/min) but regular atrial activation. Ventricular response usually has a regular pattern and a pulse of 300 beats/min. This arrhythmia is less common than AF but has similar precipitating factors, consequences, and drug therapy approach.
- The predominant mechanism of AF and atrial flutter is reentry, which is usually associated with organic heart disease that causes left atrial distention (eg, ischemia or infarction, hypertensive heart disease, and valvular disorders). Additional associated disorders include acute pulmonary embolism and chronic lung disease, resulting in pulmonary hypertension and cor pulmonale, and states of high adrenergic tone such as thyrotoxicosis, alcohol withdrawal, sepsis, and excessive physical exertion.

Paroxysmal Supraventricular Tachycardia

- PSVT arising by reentrant mechanisms includes arrhythmias caused by AV nodal reentry (AVNRT), AV reentrant tachycardia (AVRT) due to an accessory pathway, sinoatrial (SA) nodal reentry, and intraatrial reentry.

Ventricular Arrhythmias

Premature Ventricular Complexes

- Premature ventricular complexes (PVCs) can occur in patients with or without structural heart disease (SHD). PVCs may be elicited by abnormal automaticity, triggered activity, or reentrant mechanisms. PVCs often occur in healthy individuals and have little, if any, prognostic significance in this situation. PVCs occur more frequently and in more complex forms in patients with SHD than in healthy individuals, and patients with some PVC forms (multifocal or couplets) are at higher risk of sudden cardiac death.

Ventricular Tachycardia

- Ventricular tachycardia (VT) is defined by three or more repetitive PVCs occurring at a rate of >100 beats/min. It is a wide QRS tachycardia that may result acutely from severe electrolyte abnormalities (hypokalemia, hypomagnesemia), hypoxia, drug toxicity (eg, digoxin), or (most commonly) in patients presenting with acute myocardial infarction (MI) or myocardial ischemia complicated by heart failure (HF). The chronic recurrent form is almost always associated with SHD (eg, idiopathic dilated cardiomyopathy or remote MI with left ventricular [LV] aneurysm).

- Sustained VT requires intervention to restore a stable rhythm or persists for a relatively long time (usually >30 seconds). Nonsustained VT self-terminates after a brief duration (usually <30 seconds). Incessant VT refers to VT occurring more frequently than sinus rhythm, so that VT becomes the dominant rhythm. Monomorphic VT has a consistent QRS configuration, whereas polymorphic VT has varying QRS complexes. Torsade de pointes (TdP) is a polymorphic VT in which the QRS complexes appear to undulate around a central axis.

Ventricular Proarrhythmia

- Proarrhythmia is the development of a significant new arrhythmia, such as VT, ventricular fibrillation (VF), or TdP, or worsening of an existing arrhythmia. Proarrhythmia results from the same mechanisms that cause other arrhythmias or from an alteration in the underlying substrate due to an antiarrhythmic drug (AAD).

  ✔ Class Ic AADs can cause a rapid, sustained, monomorphic VT with a characteristic sinusoidal QRS pattern resulting from excessive sodium channel blockade and slowed conduction. The proarrhythmia risk continues as long as the AAD is continued. Predisposing factors include the presence of underlying ventricular arrhythmias, coronary artery disease (CAD), and LV dysfunction.

  ✔ TdP is a rapid form of polymorphic VT associated with evidence of delayed ventricular repolarization due to blockade of potassium conductance. TdP may be hereditary or acquired. Acquired forms are associated with many clinical conditions and drugs, especially class Ia and class III I_{Kr} blockers. Development of clinically significant QTc interval prolongation (ie, QTc interval >500 msec or an increase in QTc interval of >60–70 msec from baseline) after starting a drug is an indication to discontinue the agent or reduce its dose with careful monitoring.

Ventricular Fibrillation

- VF is electrical anarchy of the ventricle resulting in no cardiac output and cardiovascular (CV) collapse. Sudden cardiac death occurs most commonly in patients with CAD or LV dysfunction.

Bradyarrhythmias

- Sinus bradyarrhythmias (heart rate <60 beats/min) are common, especially in young, athletically active individuals, and are usually asymptomatic and do not require intervention. However, some patients have sinus node dysfunction (sick sinus syndrome) because of underlying SHD and the normal aging process, which attenuates SA nodal function. Sinus node dysfunction is usually representative of diffuse conduction disease, which may be accompanied by AV block and by paroxysmal tachycardias such as AF. Alternating bradyarrhythmias and tachyarrhythmias are referred to as the tachy–brady syndrome.

- AV block or conduction delay may occur in any area of the AV conduction system. AV block may be found in patients without underlying heart disease (eg, trained athletes) or during sleep when vagal tone is high. It may be transient when the underlying etiology is reversible (eg, myocarditis, myocardial ischemia, after CV surgery, or during drug therapy). β-Blockers, digoxin, or nondihydropyridine (non-DHP) calcium channel blockers (CCBs) may cause AV block, primarily in the AV nodal area. Class I AADs may exacerbate conduction delays below the level of the AV node. AV block may be irreversible if the cause is acute MI, rare degenerative diseases, primary myocardial disease, or congenital heart disease.

CLINICAL PRESENTATION

- Patients with AF or atrial flutter may complain of rapid heart rate, palpitations, chest pain, dyspnea, dizziness, and fatigue. Medical emergencies are severe HF (ie, pulmonary edema, hypotension) or AF occurring in the setting of acute MI. These arrhythmias are usually not directly life-threatening and do not generally cause hemodynamic collapse or syncope.

- PSVT caused by reentry can be transient, resulting in few, if any, symptoms. Patients may complain of intermittent episodes of rapid heart rate/palpitations that abruptly start and stop, usually without provocation (but sometimes with exercise). Patients may also complain of chest pressure or a neck sensation. Life-threatening symptoms (syncope, hemodynamic collapse) are associated with an extremely rapid heart rate (eg, >200 beats/min) and AF associated with an accessory pathway.

- PVCs are non–life-threatening and usually asymptomatic. Patients occasionally complain of palpitations or uncomfortable heartbeats. Because the PVC occurs early and the ventricle contracts when incompletely filled, patients do not feel the PVC itself; rather, the sinus beat following the PVC and

a compensatory pause is responsible for the symptoms.

- The symptoms of sustained VT (monomorphic VT or TdP) can range from nearly asymptomatic to pulseless hemodynamic collapse. Fast heart rates and underlying poor LV function result in more severe symptoms. Symptoms of nonsustained, self-terminating VT correlate with duration of episodes (eg, patients with 15-second episodes will be more symptomatic than those with three-beat episodes).
- VF results in hemodynamic collapse, syncope, and cardiac arrest. Cardiac output and blood pressure are not recordable.
- Some patients who develop proarrhythmia may be asymptomatic, others may notice worsening symptoms, and some may die suddenly.
- Symptoms of bradyarrhythmias generally result from decreased cardiac output and may be associated with hypotension (eg, dizziness, syncope, fatigue, confusion). If LV dysfunction exists, patients may experience worsening HF symptoms. Except for recurrent syncope, symptoms associated with bradyarrhythmias are often subtle and nonspecific.

DIAGNOSIS

- On ECG, AF is an irregularly irregular rhythm with no discernible, consistent atrial activity (P waves). Ventricular rate is usually 90–170 beats/min and the pulse is irregular. Atrial flutter is usually a regular supraventricular rhythm with characteristic flutter waves reflecting more organized atrial activity; the ventricular rate is often in factors of 300 beats/min (eg, 150, 100, or 75 beats/min).
- The ECG in patients with PSVT commonly shows a rapid, narrow QRS tachycardia (regular in rhythm) that starts and stops abruptly. Atrial activity, although present, is difficult to ascertain on ECG because P waves are “buried” in the QRS complex or T wave.
- Proarrhythmia can be difficult to diagnose because of the variable nature of underlying arrhythmias.
- TdP is characterized by long QT intervals or prominent U waves on the ECG.
- First-degree AV block is 1:1 AV conduction with a prolonged PR interval. Second-degree AV block is divided into two forms: Mobitz I AV block (Wenckebach periodicity) is <1:1 AV conduction with progressively lengthening PR intervals until a ventricular complex is dropped; Mobitz II AV block is intermittently dropped ventricular beats in a random fashion without progressive PR lengthening. Third-degree AV block is complete heart block where AV conduction is totally absent (AV dissociation).

TREATMENT

- Goals of Treatment: The desired outcome depends on the underlying arrhythmia. For example, the goals of treating AF or atrial flutter are restoring sinus rhythm, preventing thromboembolic complications, and preventing further recurrences.

General Approach

- Use of AADs has declined because clinical trials showed increased mortality with their use due to proarrhythmic side effects. AADs have been increasingly replaced by nonpharmacologic approaches such as ablation and the implantable cardioverter-defibrillator (ICD).

Antiarrhythmic Drugs

- Drugs may depress the automatic properties of abnormal pacemaker cells by decreasing the slope of phase 4 depolarization and/or by elevating threshold potential. Drugs may alter conduction characteristics of the pathways of a reentrant loop.
- The Vaughan Williams classification system of AADs is most frequently used for categorizing their electrophysiologic actions (**Table 6-1**).

  ✔ Class I drugs are sodium channel blockers. Class Ia drugs slow conduction velocity, prolong refractoriness, and decrease the automatic properties of sodium-dependent (normal and diseased) conduction tissue. Class Ia drugs are effective for both supraventricular and ventricular arrhythmias, but they are infrequently used because of limited efficacy and significant toxicities.

  ✔ Class Ib drugs probably act similarly to class Ia drugs, except that class Ib agents are considerably more effective in ventricular than

supraventricular arrhythmias.

✔ Class Ic drugs slow conduction velocity while leaving refractoriness relatively unaltered. Although effective for both ventricular and supraventricular arrhythmias, their use for ventricular arrhythmias has been limited by the risk of proarrhythmia.

✔ Class II drugs include β-blockers; their antiarrhythmic effects result from antiadrenergic actions. β-Blockers are most useful in tachycardias in which nodal tissues are abnormally automatic or are a portion of a reentrant loop. These agents are also helpful in slowing ventricular response in atrial tachycardias (eg, AF) by effects on the AV node.

✔ Class III drugs prolong refractoriness in atrial and ventricular tissue and include very different drugs that share the common effect of delaying repolarization by blocking potassium channels. **Amiodarone** and **sotalol** are effective in most supraventricular and VTs. Amiodarone displays electrophysiologic characteristics of all four Vaughan Williams classes. It is a sodium channel blocker with relatively fast on–off kinetics, has nonselective β-blocking actions, blocks potassium channels, and has slight calcium-blocking activity. Sotalol inhibits outward potassium movement during repolarization and also possesses nonselective β-blocking actions. **Dronedarone**, **ibutilide**, and **dofetilide** are indicated only for treatment of supraventricular arrhythmias.

✔ Class IV drugs include the non-DHP CCBs (**verapamil**, **diltiazem**), which inhibit calcium entry into cells, thereby slowing conduction, prolonging refractoriness, and decreasing SA and AV nodal automaticity. They are effective for automatic or reentrant tachycardias that arise from or use the SA or AV nodes.

- See **Table 6-2** for recommended doses of oral AADs, **Table 6-3** for usual IV antiarrhythmic doses, and **Table 6-4** for common side effects.

TABLE 6-1

Classification of Antiarrhythmic Drugs

Class	Drug	Conduction Velocity[a]	Refractory Period	Automaticity	Ion Block
Ia	Quinidine Procainamide Disopyramide	↓	↑	↓	Sodium (intermediate) Potassium
Ib	Lidocaine Mexiletine	0/↓	↓	↓	Sodium (fast on–off)
Ic	Flecainide Propafenone[b]	↓↓	0	↓	Sodium (slow on–off)
II[c]	β-Blockers	↓	↑	↓	Calcium (indirect)
III	Amiodarone[d] Dofetilide Dronedarone[d] Sotalol[b] Ibutilide	0	↑↑	0	Potassium
IV[c]	Verapamil Diltiazem	↓	↑	↓	Calcium

[a]Variables for normal tissue models in ventricular tissue.

[b]Also has β-blocking actions.

[c]Variables for sinoatrial (SA) and atrioventricular (AV) nodal tissue only.

[d]Also has sodium, calcium, and β-blocking actions.

0, no change; ↑, increased; ↓, decreased.

TABLE 6-2

Typical Maintenance Doses of Oral Antiarrhythmic Drugs

Drug	Dose	Dose Adjusted
Disopyramide	100–150 mg every 6 hours 200–300 mg every 12 hours (SR form)	HEP, REN
Quinidine	200–300 mg sulfate salt every 6 hours 324–648 gluconate salt every 8–12 hours	HEP
Mexiletine	200–300 mg every 8 hours	HEP
Flecainide	50–200 mg every 12 hours	HEP, REN
Propafenone	150–300 mg every 8 hours 225–425 mg every 12 hours (SR form)	HEP
Amiodarone	400 mg 2 or 3 times daily until 10 g total, and then 200–400 mg daily[a]	
Dofetilide	500 mcg every 12 hours	REN[b]
Dronedarone	400 mg twice daily (with meals)[c]	
Sotalol	80–160 mg every 12 hours	REN[d]

[a]Usual maintenance dose for atrial fibrillation is 200 mg/day (may further decrease dose to 100 mg/day with long-term use if patient clinically stable in order to decrease risk of toxicity); usual maintenance dose for ventricular arrhythmias is 300–400 mg/day.

[b]Dose should be based on creatinine clearance; should not be used when creatinine clearance <20 mL/min.

[c]Should not be used in severe hepatic impairment.

[d]Should not be used for atrial fibrillation when creatinine clearance <40 mL/min.

HEP, hepatic disease; REN, renal impairment; SR, sustained release.

TABLE 6-3

Intravenous Antiarrhythmic Dosing

Drug	Clinical Situation	Dose
Amiodarone	Pulseless VT/VF	300 mg IV/IO push (can give additional 150 mg IV/IO push if persistent VT/VF or if VT/VF recurs), followed by infusion of 1 mg/min for 6 hours, and then 0.5 mg/min × 18 hours
	Stable VT (with a pulse)	150 mg IV over 10 min, followed by infusion of 1 mg/min for 6 hours, and then 0.5 mg/min × 18 hours
	AF (termination)	150 mg IV over 10 min, followed by infusion of 1 mg/min for 6 hours, and then 0.5 mg/min × 18 hours
Diltiazem	PSVT; AF (rate control)	0.25 mg/kg IV over 2 min (may repeat with 0.35 mg/kg IV over 2 min), followed by infusion of 5–15 mg/hr
Ibutilide	AF (termination)	1 mg IV over 10 min (may repeat if needed)
Lidocaine	Pulseless VT/VF	1–1.5 mg/kg IV/IO push (can give additional 0.5–0.75 mg/kg IV/IO push every 5–10 min if persistent VT/VF [maximum cumulative dose = 3 mg/kg]), followed by infusion of 1–4 mg/min (1–2 mg/min if liver disease or HF)
	Stable VT (with a pulse)	1–1.5 mg/kg IV push (can give additional 0.5–0.75 mg/kg IV push every 5–10 min if persistent VT [maximum cumulative dose = 3 mg/kg]), followed by infusion of 1–4 mg/min (1–2 mg/min if liver disease or HF)
Procainamide	AF (termination); stable VT (with a pulse)	15–18 mg/kg IV over 60 min, followed by infusion of 1–4 mg/min
Verapamil	PSVT; AF (rate control)	2.5–5 mg IV over 2 min (may repeat up to maximum cumulative dose of 20 mg); can follow with infusion of 2.5–10 mg/hr

AF, atrial fibrillation; HF, heart failure; IO, intraosseous; IV, intravenous; PSVT, paroxysmal supraventricular tachycardia; VF, ventricular fibrillation; VT, ventricular tachycardia.

TABLE 6-4

Side Effects of Antiarrhythmic Drugs

Disopyramide	Anticholinergic symptoms (dry mouth, urinary retention, constipation, blurred vision), nausea, anorexia, TdP, HF, conduction disturbances, ventricular arrhythmias
Procainamide[a]	Hypotension, TdP, worsening HF, conduction disturbances, ventricular arrhythmias
Quinidine	Cinchonism, diarrhea, abdominal cramps, nausea, vomiting, hypotension, TdP, worsening HF, conduction disturbances, ventricular arrhythmias, fever
Lidocaine	Dizziness, sedation, slurred speech, blurred vision, paresthesia, muscle twitching, confusion, nausea, vomiting, seizures, psychosis, sinus arrest, conduction disturbances
Mexiletine	Dizziness, sedation, anxiety, confusion, paresthesia, tremor, ataxia, blurred vision, nausea, vomiting, anorexia, conduction disturbances, ventricular arrhythmias
Flecainide	Blurred vision, dizziness, dyspnea, headache, tremor, nausea, worsening HF, conduction disturbances, ventricular arrhythmias
Propafenone	Dizziness, fatigue, blurred vision, bronchospasm, headache, taste disturbances, nausea, vomiting, bradycardia or AV block, worsening HF, ventricular arrhythmias
Amiodarone	Tremor, ataxia, paresthesia, insomnia, corneal microdeposits, optic neuropathy/neuritis, nausea, vomiting, anorexia, constipation, TdP (<1%), bradycardia or AV block (IV and oral use), pulmonary fibrosis, liver function test abnormalities, hypothyroidism, hyperthyroidism, photosensitivity, blue-gray skin discoloration, hypotension (IV use), phlebitis (IV use)
Dofetilide	Headache, dizziness, TdP
Dronedarone	Nausea, vomiting, diarrhea, serum creatinine elevations, bradycardia, worsening HF, hepatotoxicity, pulmonary fibrosis, acute renal failure, TdP (<1%)
Ibutilide	Headache, TdP, bradycardia or AV block, hypotension
Sotalol	Dizziness, weakness, fatigue, nausea, vomiting, diarrhea, bradycardia or AV block, TdP, bronchospasm, worsening HF

[a]Side effects listed are for the IV formulation only; oral formulations are no longer available.

AV, atrioventricular; HF, heart failure; IV, intravenous; TdP, torsade de pointes.

Atrial Fibrillation or Atrial Flutter

- Treatment of AF involves several sequential goals. First, evaluate need for acute treatment (usually with drugs that slow ventricular rate). Second, determine whether an attempt should be made to restore the patient to SR, taking into consideration the risks (eg, thromboembolism). Lastly, consider ways to prevent long-term complications, such as recurrent arrhythmia and thromboembolism (**Fig. 6-1**).

FIGURE 6-1

Algorithm for the treatment of AF and atrial flutter.

(AAD, antiarrhythmic drug; AF, atrial fibrillation; AFl, atrial flutter; BB, β-blocker; CCB, calcium channel blocker [ie, verapamil or diltiazem]; DCC, direct

current cardioversion; TEE, transesophageal echocardiogram.)

Hemodynamically Unstable AF

- In patients with new-onset AF or atrial flutter with signs and/or symptoms of hemodynamic instability (eg, severe hypotension, angina, and/or pulmonary edema), direct-current cardioversion (DCC) is indicated to restore sinus rhythm immediately (without regard to the risk of thromboembolism).

Ventricular Rate Control

- If patients are hemodynamically stable, the focus should be directed toward controlling ventricular rate. Use drugs that slow conduction and increase refractoriness in the AV node as initial therapy. In patients with normal LV function (left ventricular ejection fraction [LVEF] >40% [0.40]), an IV β-blocker (**propranolol**, **metoprolol**, **esmolol**) or non-DHP CCB (**diltiazem**, **verapamil**) is recommended as first-line therapy. If a high adrenergic state is the precipitating factor, IV β-blockers should be considered first. In patients with LVEF ≤40% (0.40), avoid IV diltiazem and verapamil and use IV β-blockers with caution. In patients having an exacerbation of HF symptoms, use IV **digoxin** or **amiodarone** as first-line therapy for ventricular rate control. IV amiodarone can also be used in patients who are refractory or have contraindications to β-blockers, non-DHP CCBs, and digoxin.

- After treatment with AV nodal blocking agents and a subsequent decrease in ventricular rate, evaluate the patient for the possibility of restoring sinus rhythm if AF persists.

Anticoagulation Prior to Cardioversion

- If sinus rhythm is to be restored, initiate anticoagulation prior to cardioversion because return of atrial contraction may dislodge poorly adherent thrombi and increase the risk of thromboembolism. Initiating anticoagulation prior to cardioversion prevents clot growth and formation of new thrombi and allows existing thrombi to become organized and well adherent to the atrial wall. Patients become at increased risk of thrombus formation and a subsequent embolic event if the duration of AF exceeds 48 hours.

- Patients undergoing elective cardioversion for AF lasting longer than 48 hours or an unknown duration should receive **warfarin** (target international normalized ratio [INR] 2–3) or a direct oral anticoagulant (DOAC; **apixaban**, **dabigatran**, **edoxaban**, or **rivaroxaban**) for at least 3 weeks prior to cardioversion. If cardioversion is successful, continue anticoagulation for at least 4 weeks.

- Patients with AF less than 48 hours in duration do not require a prolonged period of anticoagulation prior to cardioversion because there has not been sufficient time to form atrial thrombi. Recommendations regarding short-term anticoagulation therapy given immediately prior to cardioversion differ. The CHEST guidelines recommend anticoagulation with either IV **unfractionated heparin** (UFH) or subcutaneous **low-molecular-weight heparin** (LMWH) (with doses used for treating venous thromboembolism) at the time the patient presents with AF that is known to be less than 48 hours in duration. If the patient is successfully cardioverted to sinus rhythm, continue therapeutic anticoagulation with warfarin (INR target range 2–3) or a DOAC for at least 4 weeks. Decisions about long-term antithrombotic therapy beyond 4 weeks should be based on the patient's risk for stroke and not whether the patient is in sinus rhythm. According to the 2019 AHA/ACC/HRS Focused Update, the anticoagulant regimen selected depends on the patient's risk of stroke (refer to the textbook chapter for more information).

Conversion to Sinus Rhythm

- After anticoagulation needs have been addressed (or after transesophageal echocardiography [TEE] demonstrated absence of a thrombus, obviating need for anticoagulation), methods for restoring sinus rhythm are pharmacologic cardioversion and DCC. Disadvantages of pharmacologic cardioversion are the risk of significant side effects (eg, drug-induced TdP, drug–drug interactions) and lower cardioversion rate for AADs compared with DCC. DCC is quick and more often successful (80%–90% success rate), but it requires prior sedation or anesthesia and has a small risk of serious complications, such as sinus arrest or ventricular arrhythmias. Clinicians often elect to use AADs first, and then resort to DCC if these drugs fail. Pharmacologic cardioversion is most effective when initiated within 7 days after the onset of AF. There is good evidence for cardioversion efficacy of class III pure Ik blockers (**ibutilide, dofetilide**), class Ic drugs (eg, **flecainide**, **propafenone**), and **amiodarone** (oral or IV).

- Single oral loading doses of propafenone (body weight >70 kg: 600 mg; <70 kg: 450 mg) and flecainide (body weight >70 kg: 300 mg; <70 kg: 200 mg) are effective for cardioversion of recent-onset AF. These regimens have been incorporated into the "pill in the pocket" approach, whereby outpatient, patient-controlled self-administration of a single oral dose of either flecainide or propafenone is used to terminate recent-onset AF in select patients without sinus or AV node dysfunction, bundle-branch block, or SHD. This method should only be considered for patients who have been successfully cardioverted with these drugs on an inpatient basis.

Chronic Anticoagulation for Stroke Prevention

- When initiating chronic antithrombotic therapy to prevent stroke in patients with AF, selection of the appropriate regimen is based on the patient's stroke risk as determined by the CHA_2DS_2-Vasc risk scoring system. Patients are given 2 points each if they have a history of a previous stroke, transient ischemic attack, or thromboembolism, or if they are at least 75 years old. Patients are given 1 point each for age 65–74 years; having hypertension, diabetes, HF, or vascular disease; and being female.

  ✔ *Low risk*: No antithrombotic therapy is recommended for males with a CHA_2DS_2-VASc score of 0 and females with a score of 1 because they are at low risk for stroke.

  ✔ *Intermediate risk*: For patients with one nonsex stroke risk factor (ie, CHA_2DS_2-VASc score of 1 in males or 2 in females), oral anticoagulation is recommended over aspirin monotherapy, aspirin plus clopidogrel, or no antithrombotic therapy.

  ✔ *High risk*: For patients with more than one nonsex stroke risk factor (ie, CHA_2DS_2-VASc score of ≥2 in males or ≥3 in females), oral anticoagulation is also recommended.

- For stroke prevention in AF, the CHEST guidelines recommend a DOAC (apixaban, dabigatran, edoxaban, or rivaroxaban) over warfarin. However, anticoagulant therapy must be individualized for each patient. If warfarin is used, the target INR is 2–3, and the goal time in therapeutic range (TTR) should ideally be >70%. If a therapeutic INR cannot be maintained on warfarin, a DOAC is recommended. If treatment with oral anticoagulation must be temporarily interrupted, coverage with parenteral UFH or LMWH should be considered.

- In patients with mechanical heart valves, warfarin is the anticoagulant of choice; the target INR is based on the type and location of the valve placed. Dabigatran, edoxaban, and rivaroxaban should be avoided in patients with creatinine clearance <15 mL/min (0.25 mL/sec).

- Decisions regarding the duration of chronic antithrombotic therapy should be based on a patient's risk for stroke using the CHA_2DS_2-VASc scoring system.

Chronic Antiarrhythmic Therapy

- Use of AADs to prevent AF recurrences is controversial; AADs may be reasonable in patients who remain symptomatic despite having adequate ventricular rate control or for patients in whom adequate ventricular rate control cannot be achieved.

- In patients with no SHD, **dofetilide**, **dronedarone**, **flecainide**, **propafenone**, or **sotalol** should be considered initially. **Amiodarone** is second-line if the patient fails or does not tolerate one of these drugs. In patients with HF, amiodarone or dofetilide is first-line therapy, with catheter ablation as second-line. In patients with CAD dofetilide, dronedarone, or sotalol are first-line, with amiodarone as second-line therapy. Flecainide and propafenone should be avoided in the presence of SHD because of the risk of proarrhythmia.

Paroxysmal Supraventricular Tachycardia

- Both pharmacologic and nonpharmacologic methods have been used to treat PSVT. Drugs can be divided into three broad categories: (1) those that directly or indirectly increase vagal tone to the AV node (eg, digoxin), (2) those that depress conduction through slow, calcium-dependent tissue (eg, adenosine, β-blockers, and non-DHP CCBs), and (3) those that depress conduction through fast, sodium-dependent tissue (eg, quinidine, procainamide, disopyramide, and flecainide). Drugs within these categories alter the electrophysiologic characteristics of the reentrant substrate so that PSVT cannot be sustained.

- Acute management for patients with AVNRT or orthodromic AVRT includes vagal maneuvers and/or adenosine. If these options are ineffective or

unfeasible in a hemodynamically unstable patient, synchronized DCC is the next step. If vagal techniques and adenosine are ineffective or unfeasible in a hemodynamically stable patient, the next step is administration of an IV β-blocker or non-DHP CCB. If AVNRT cannot be corrected with these measures, IV amiodarone can be used. For patients with AVRT, the next step is synchronized cardioversion.

- After an acute episode of AVNRT or AVRT is terminated, long-term prophylaxis is indicated if frequent episodes necessitate therapeutic intervention or if episodes are infrequent but severely symptomatic. AADs are no longer the treatment of choice to prevent recurrences of reentrant PSVT but may be necessary occasionally, particularly in patients with mild symptoms and infrequent recurrences. Drugs effective in preventing recurrences are the AV nodal blocking drugs (digoxin, β-blockers, non-DHP CCBs, and combinations of these agents) and the class Ic AADs (flecainide, propafenone). Sotalol, dofetilide, and amiodarone can be considered alternatives.

- Catheter ablation using radiofrequency current on the PSVT substrate is the preferred treatment strategy (over AADs) for patients with symptomatic PSVT. It is highly effective and curative, rarely results in complications, obviates need for chronic AAD therapy, and is cost effective.

Premature Ventricular Complexes

- In apparently healthy individuals without SHD, drug therapy is unnecessary because PVCs carry little or no risk. In addition, AADs should not be used to suppress asymptomatic PVCs. In patients with symptomatic PVCs who have risk factors for arrhythmic death (recent MI, LV dysfunction, or complex PVCs), limit chronic therapy to β-blockers. β-Blockers can also be used to suppress symptomatic PVCs in patients without underlying heart disease.

Ventricular Tachycardia

Acute Ventricular Tachycardia

- If severe symptoms are present, institute synchronized DCC immediately to restore sinus rhythm and correct precipitating factors if possible. If VT is an isolated electrical event associated with a transient initiating factor (eg, acute myocardial ischemia or digitalis toxicity), there is no need for long-term antiarrhythmic therapy after precipitating factors are corrected.

- Patients with mild or no symptoms can be treated initially with AADs. IV procainamide, amiodarone, or sotalol may be considered in this situation; lidocaine is an alternative agent. Deliver synchronized DCC if the patient's status deteriorates, VT degenerates to VF, or drug therapy fails.

Sustained Ventricular Tachycardia

- Patients with chronic recurrent sustained VT are at high risk for death; trial-and-error attempts to find effective therapy are unwarranted. Use of invasive electrophysiologic studies and serial Holter monitoring with drug testing have been largely abandoned. These findings and the side-effect profiles of antiarrhythmic agents have led to nondrug approaches.

- The automatic ICD is a highly effective method for preventing sudden death due to recurrent VT or VF.

Ventricular Proarrhythmia

- The proarrhythmia caused by the class Ic AADs is often resistant to resuscitation with cardioversion or overdrive pacing. IV **lidocaine** (which competes for the sodium channel receptor) or **sodium bicarbonate** (which reverses the excessive sodium channel blockade) has been used successfully by some clinicians.

Torsade de Pointes

- For an acute episode of TdP, most patients require and respond to DCC. However, TdP tends to be paroxysmal and often recurs rapidly after DCC.

- IV **magnesium sulfate** is the drug of choice for preventing recurrences of TdP. If ineffective, institute strategies to increase heart rate and shorten ventricular repolarization (ie, temporary transvenous pacing at 105–120 beats/min or pharmacologic pacing with **isoproterenol**). Discontinue agents that prolong the QT interval and correct exacerbating factors (eg, hypokalemia and hypomagnesemia). Lidocaine is usually ineffective, and AADs that further prolong repolarization (eg, IV procainamide) are absolutely contraindicated.

Ventricular Fibrillation

- Manage patients with pulseless VT or VF (with or without associated myocardial ischemia) according to American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care (see Chapter 7).

Bradyarrhythmias

- Asymptomatic sinus bradyarrhythmias usually do not require treatment.
- Treatment of sinus node dysfunction involves eliminating symptomatic bradycardia and potentially managing alternating tachycardias such as AF. In general, permanent pacemaker implantation is the long-term therapy of choice. Drugs commonly used to treat supraventricular tachycardias should be used with caution, if at all, in the absence of a functioning pacemaker.
- Symptomatic carotid sinus hypersensitivity also should be treated with permanent pacemaker therapy. Patients who remain symptomatic may benefit from adding an α-adrenergic stimulant such as **midodrine**.
- Vasovagal syncope has traditionally been treated successfully with oral β-blockers (eg, **metoprolol**) to inhibit the sympathetic surge that causes forceful ventricular contraction and precedes the onset of hypotension and bradycardia. Other drugs that have been used successfully (with or without β-blockers) include **fludrocortisone**, anticholinergics (**scopolamine patches** and **disopyramide**), α-adrenergic agonists (**midodrine**), adenosine analogues (**theophylline**, **dipyridamole**), and selective serotonin reuptake inhibitors (**sertraline**, **paroxetine**).

Atrioventricular Block

- If patients with second- or third-degree AV block develop signs or symptoms of poor perfusion (eg, altered mental status, chest pain, hypotension, shock) administer **atropine** (0.5 mg IV given every 3–5 minutes, up to 3 mg total dose). Transcutaneous pacing can be initiated in patients unresponsive to atropine. Infusions of **epinephrine** (2–10 mcg/min) or **dopamine** (2–10 mcg/kg/min) can also be used in the event of atropine failure. These agents usually do not help if the site of the AV block is below the AV node (Mobitz II or trifascicular AV block).
- Chronic symptomatic AV block warrants insertion of a permanent pacemaker. Patients without symptoms can sometimes be followed closely without the need for a pacemaker.

EVALUATION OF THERAPEUTIC OUTCOMES

- The most important monitoring parameters include: (1) mortality (total and sudden cardiac death), (2) arrhythmia recurrence (duration, frequency, and symptoms), (3) hemodynamic consequences (rate, blood pressure, and symptoms), and (4) treatment complications (side effects or need for alternative or additional drugs, devices, or surgery).

See Chapter 39, The Arrhythmias, authored by Jessica J. Tilton, Cynthia A. Sanoski, and Jerry L. Bauman, for a more detailed discussion of this topic.