

## CARDIAC ELECTROPHYSIOLOGY, ARRHYTHMIAS AND PACING

### Medical Knowledge

Goals and Objectives	PF	EF	MF	LF	Aspirational
<ul style="list-style-type: none"> <li>Know the histology and gross anatomy of the normal sinoatrial node, atrial conduction pathways, atrioventricular (AV) junction and nod, His bundle, conduction fascicles and terminal intra-ventricular conduction pathways</li> </ul>	X				
<ul style="list-style-type: none"> <li>Know the normal electrophysiologic properties of the aforementioned structures</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the relation of the autonomic nervous system to cardiac arrhythmias and conduction disturbances</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the physiology of sodium, potassium and calcium ion channels</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the phases of cardiac action potential</li> </ul>	X				
<ul style="list-style-type: none"> <li>Know the electrophysiologic characteristics, including ionic alterations of phases 0, 1, 2, 3, and 4 in different cardiac locations</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the electrophysiologic characteristics of normal automaticity</li> </ul>	X				

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<ul style="list-style-type: none"><li>• Know the definitions and characteristics of disorders of impulse formation including enhanced and depressed automaticity in different pacemaker sites, triggered activity early after-depolarizations, the congenital long QT syndromes, delayed after depolarizations and parasystole</li></ul>			X		
<ul style="list-style-type: none"><li>• Know the definitions and electrophysiologic characteristics of disorders of conduction including deceleration-dependent block, tachycardia-dependent block, tachycardia-dependent block, decremental conduction, re-entry and entrainment</li></ul>			X		
<ul style="list-style-type: none"><li>• Know the difference between anatomic and functional re-entry</li></ul>			X		
<ul style="list-style-type: none"><li>• Know the differences among loop re-entry, leading circle form of re-entry, figure of eight re-entry and anisotropic re-entry</li></ul>			X		

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<ul style="list-style-type: none"> <li>Know the electrophysiologic mechanisms that cause supraventricular re-entry tachycardias including atrial fibrillation, atrial flutter, sinus node re-entry tachycardia, atrial re-entry tachycardia, AV nodal re-entry tachycardias and accessory pathway (reciprocating) tachycardias</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the electrophysiologic and electroanatomic characteristics of the pre-excitation syndrome</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the electrophysiologic mechanisms that cause ventricular monomorphic re-entry ventricular tachycardia, ventricular tachycardia associated with the Brugada syndrome, catecholaminergic ventricular tachycardia and ventricular fibrillation</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the symptoms that may be caused by various cardiac arrhythmias and conduction disturbances</li> </ul>		X			
<ul style="list-style-type: none"> <li>Know the abnormalities on the physical examination that are associated with cardiac arrhythmias and conduction disturbances</li> </ul>		X			

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<ul style="list-style-type: none"><li>• Know the role of the standard 12 lead electrocardiogram in the diagnosis of cardiac arrhythmias</li></ul>		X			
<ul style="list-style-type: none"><li>• Know how to apply Lewis ladder diagrams in the diagnosis of cardiac arrhythmias and conduction disturbances</li></ul>		X			
<ul style="list-style-type: none"><li>• Know the role of exercise testing in the detection of cardiac arrhythmias and conduction disturbances</li></ul>		X			
<ul style="list-style-type: none"><li>• Know the role of long-term electrocardiographic monitoring (Holter monitoring, external loop recorders, implantable loop recorders) in the detection of cardiac arrhythmias and conduction disturbances</li></ul>		X			

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<ul style="list-style-type: none"><li>• Know the role of heart rate variability testing in assess the risk of cardiac arrhythmias</li></ul>				X	
<ul style="list-style-type: none"><li>• Know the relation of QTc and QT dispersion in assessing the risk of cardiac arrhythmias</li></ul>			X		
<ul style="list-style-type: none"><li>• Know the role of signal averaged electrocardiography in assessing the risk of cardiac arrhythmias</li></ul>				X	
<ul style="list-style-type: none"><li>• Know the role of assessment for T wave alternans for determining the risk of cardiac arrhythmias</li></ul>				X	
<ul style="list-style-type: none"><li>• Know the role of head-up tilt testing in detection of abnormal cardiac rhythms</li></ul>			X		
<ul style="list-style-type: none"><li>• Know the role of esophageal electrocardiography in arrhythmia diagnosis</li></ul>				X	

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<ul style="list-style-type: none"> <li>Know the protocols and diagnostic value of invasive studies of cardiac conduction including sinus node function test and studies of intra-atrial, AV nodal and intra-ventricular conduction</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the protocols and diagnostic value of invasive electrophysiologic studies assessing tachycardias including intracardiac mapping and programmed electrical stimulation</li> </ul>				X	
<ul style="list-style-type: none"> <li>Know the role of drug therapy in patients undergoing invasive electrophysiologic studies</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the role of invasive electrophysiologic studies in the evaluation of patients with unexplained synope and palpitations</li> </ul>				X	
<ul style="list-style-type: none"> <li>Know the specific indications for invasive cardiac conduction studies and invasive cardiac electrophysiology studies</li> </ul>			X		

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<ul style="list-style-type: none"> <li>• Know the complications of invasive cardiac conduction and electrophysiology studies</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the ACC/AHA guidelines for clinical intracardiac electrophysiologic studies for evaluation of specific electrocardiographic abnormalities and evaluation of clinical syndromes</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the ACC/AHA guidelines for clinical intracardiac electrophysiologic studies for therapeutic intervention</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the Vaughn-Williams classification of anti-arrhythmic drugs. Know the drugs in each class and their general electropysiologic properties</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Know the ion channel, receptor and pump physiology and pharmacology as well as the clinical effects of currently available anti-arrhythmic drugs including quinidine, procainamide, disopyramide, amjaline, lidocaine, mexiletene, phenytoin, flecainde, propafenone, propranolol, nadolol, amiodarone, dronedarone, sotalol, dofetilide, ibutilide, verapamil, diltiazem, adenosine, digoxin and atropine</li> </ul>			X		

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<ul style="list-style-type: none"> <li>Know the doses (loading and maintenance) administration, to time to peak plasma concentration, effective serum concentration, half-life, bioavailability, major routes of elimination and pregnancy class of antiarrhythmic drugs</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the in vivo electrophysiologic and hemodynamic characteristics of anti-arrhythmic drugs</li> </ul>				X	
<ul style="list-style-type: none"> <li>Know the indications for use of the aforementioned drugs for treatment of cardiac arrhythmias and conduction disturbances</li> </ul>		X			
<ul style="list-style-type: none"> <li>Know the side effects of anti-arrhythmic drugs including pro-arrhythmia</li> </ul>		X			
<ul style="list-style-type: none"> <li>Know the anti-arrhythmic effects of non-antiarrhythmic drugs (eg, ranolazine, statins, angiotensin and aldosterone receptor blockers)</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the mechanisms and technique of DC electrocardioversion</li> </ul>		X			

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<ul style="list-style-type: none"> <li>• Know the indications for, expected results of and complications of DC cardioversion</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Know the various types of ablation therapy of cardiac arrhythmias</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know the equipment required for radio frequency ablation</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know how to identify the ablation site using intra-cardiac electrograms know the electroanatomic characteristics important in radio frequency ablation</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know the indications for and the radio frequency ablation</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the differences in the aforementioned goals for ablation of different arrhythmias including AV nodal re-entry tachycardias, ectopic junctional tachycardia, atrial and sinus node re-entry tachycardias, AV reciprocating tachycardias (accessory pathway tachycardias and ventricular tachycardia</li> </ul>				X	

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<ul style="list-style-type: none"> <li>• Have a general knowledge of the background and role of surgical therapy of tachyarrhythmias including ventricular tachycardia</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know the background of cardiac electrical stimulation including local and global effects, thresholds, wave forms and strength and duration effects</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know the hemodynamics of cardiac electrical stimulation including the chronotropic response, AV synchrony and the rationale for cardiac resynchronization therapy</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know the characteristics of pacemaker hardware including leads and pulse generator components</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the mechanisms of sensing in cardiac pacemakers and ICD's including the role of blanking periods, refractory periods, sensing thresholds and sensing-related optimization of pacemaker function</li> </ul>			X		

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<ul style="list-style-type: none"> <li>• Know how ICD's detect ventricular tachycardia and fibrillation, how they discriminate between supraventricular and ventricular tachycardia and how they confirm tachycardia termination</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know pacemaker modes and timing cycles including those for VVI, AAI, DDI and DDD pacing. Know the role of rate adaptive sensors</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the types of electrical therapy of ventricular tachyarrhythmia including tiered therapy, anti-tachycardia pacing, the effects of cardioversion and defibrillation shocks and shock reduction</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know the steps in troubleshooting common pacemaker problems including failure to pace, failure to capture, failure to sense, pacing at a non-programmed rate, adverse consequences of appropriate capture and sensing and misinterpretation of normal pacemaker function</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know the steps in troubleshooting ICD's including trouble shooting shocks, unsuccessful shocks, failure to deliver appropriate therapy or delayed therapy</li> </ul>				X	

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<ul style="list-style-type: none"> <li>• Know the steps in trouble-shooting cardiac resynchronization pacing</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know the complications of pacemaker and ICD therapy including implant-related complications, lead-related complications and device system infection</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the process of pacemaker surveillance and follow up via office visits or Ransletephonic monitoring</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the ACC/AHA indication guidelines for implantation of cardiac pacemakers and ICD's for AV block, chronic bifascicular and incomplete trifascicular block, conduction disturbances in the midst of myocardial infarction, sinus node dysfunction, to terminate tachycardia, to prevent tachycardia, for hypertrophic cardiomyopathy for neutrall- medicated and reflex syncope, after cardiac transplantation and for cardiac resynchronization therapy</li> </ul>		X			

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Goals and Objectives	PF	EF	MF	LF	Aspirational
• Know the ACC/AHA guidelines for choice of pacemaker			X		
• Know the ACC/AHA indication guidelines for indications for permanent pacing in adolescents and adults with congenital heart disease				X	
• Know the ACC/AHA indication guidelines for indications for ICD therapy			X		
• Know the AHA/NASPE guidelines for safe resumption of activity after pacemaker or ICD implantation			X		

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<ul style="list-style-type: none"> <li>Know how to identify the following arrhythmias by history, physical examination, standard 12 lead electrocardiogram, long-term electrocardiographic monitoring or by cardiac conduction or invasive electrophysiologic study: sinus tachycardia, premature atrial complexes, premature junctional complexes, atrial fibrillation, atrial flutter, atrial tachycardias (re-entry and automatic), AV junctional tachycardias, (re-entry and automatic, reciprocating (accessory pathway) tachycardias, ventricular tachycardias) (re-entry, automatic, triggered), ventricular flutter, ventricular fibrillation, sinus bradycardia, sinus arrest and block, bradycardia/tachycardia) syndrome, 1° AV block, 2° AV block (types I and II), 3° AV block (AV nodal, infra-nodal), AV dissociation, reciprocal beats and rhythms, asystole, agonal rhythm, pulse less electrical activity</li> </ul>			X		
<ul style="list-style-type: none"> <li>Know the principles of management for each of the aforementioned arrhythmias and conduction disturbances based on clinical factors, natural history, electrophysiologic information and prior treatment history. Take into consideration all treatment modalities.</li> </ul>			X		

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Goals and Objectives	PF	EF	MF	LF	Aspirational
<ul style="list-style-type: none"><li>• Know the definitions of sudden cardiac death and sudden cardiac arrest</li></ul>		X			
<ul style="list-style-type: none"><li>• Know the epidemiology of sudden cardiac death</li></ul>			X		
<ul style="list-style-type: none"><li>• Know the risk factors for sudden cardiac death including genetic contributors, the role of functional capacity, the role of life style and psychosocial factors, the factors of LVEF and ventricular arrhythmias in chronic ischemic heart disease and emerging markers of sudden cardiac death risk</li></ul>			X		
<ul style="list-style-type: none"><li>• Know the causes and contributing factors to sudden cardiac death in the presence and absence of coronary artery disease</li></ul>			X		
<ul style="list-style-type: none"><li>• Know coronary artery disease-related causes of sudden cardiac death including pathology and mechanisms</li></ul>			X		
<ul style="list-style-type: none"><li>• Know the relationship of ventricular hypertrophy and hypertrophic cardiomyopathy to sudden cardiac death</li></ul>			X		

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<ul style="list-style-type: none"> <li>• Know the relationship of dilated cardiomyopathy to sudden cardiac death</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the relation of heart failure (acute and chronic) to sudden cardiac death</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Know the relation of electrophysiologic abnormalities to sudden cardiac death including the long QT syndromes, early, repolarization, catecholaminergic polymorphic ventricular tachycardia and electrical instability from neuro-humoral/CNS abnormalities</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the pathophysiology of sudden cardiac death caused by coronary artery abnormalities</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the mechanisms and pathophysiology of sudden cardiac death in general including pathophysiologic mechanisms of lethal tachyarrhythmias and the pathophysiologic changes of brady-arrhythmias asystole and pulseless electrical activity</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Know the clinical features of patients with cardiac arrest including prodromal symptoms, onset of the terminal event, cardiac arrest progression to biologic death</li> </ul>		X			

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<ul style="list-style-type: none"> <li>• Know the clinical characteristics of survivors of cardiac arrest including in-hospital and long-term prognosis</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know community-based interventions for cardiac arrest including the impact of response systems and the importance of electrical mechanisms</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Know initial assessment and basic life support protocols as recommended by AHA guidelines</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Know advanced cardiac life support (ACLS) protocols as recommended by AHA guidelines</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Know the specifics of post-cardiac arrest care in different clinical situations as recommend by AHA guidelines</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Know strategies to reduce the risk of sudden cardiac death including anti-arrhythmic drug therapy, ICD implantation, catheter ablation therapy, surgical intervention</li> </ul>			X		

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Goals and Objectives	PF	EF	MF	LF	Aspirational
<ul style="list-style-type: none"><li>• Know how different therapeutic strategies to decrease the risk of sudden cardiac death apply to specific groups of patients including secondary prevention and primary prevention strategies</li></ul>			X		

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Be able to:					
• Recognize symptoms that may be caused by cardiac arrhythmias and conduction disturbances		X			
• Recognize physical examination findings associated with cardiac arrhythmias and conduction disturbances		X			
• Implement Lewis ladder diagrams to characterize cardiac arrhythmias and conduction disturbances			X		
• Utilize ambulatory electrocardiographic monitoring and exercise testing to detect cardiac arrhythmias and conduction disturbances		X			
• Utilize assessment of heart rate variability, QT dispersion and late potentials on signal-average electrocardiogram and T wave to alertness identify arrhythmic substrate			X		

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• Perform and interpret the results of head-up tilt testing			X		
• Perform esophageal electrocardiography to detect cardiac arrhythmias and conduction disturbances					X
• Perform and interpret invasive cardiac conduction tests including sinus node function tests and His bundle studies				X	
• Identify components of the normal intra-cardiac electrogram obtained during invasive electrophysiologic studies			X		
• Interpret straightforward intra-cardiac electrograms obtained during invasive electrophysiologic testing in patients with re-entry supra-ventricular tachycardias, AV reciprocating (accessory pathway) tachycardias and ventricular tachycardias				X	
• Perform at least 10 direct current cardioversions under faculty supervision				X	

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<ul style="list-style-type: none"> <li>• Perform and interpret at least 5 cardiac conduction studies under faculty supervision</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Assist faculty electrophysiologists in the performance of intra-cardiac electro-cardiographic mapping, programmed electrical stimulation, ablation of dual AV nodal and accessory pathway tachycardia AV nodal ablation and pulmonary vein isolation. Be able to interpret electrophysiologic study results for cases in which you participated</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Implant VVI-R, DVI-R, DDD and AAI permanent pacemakers under faculty supervision</li> </ul>				X	
<ul style="list-style-type: none"> <li>• Implant single and dual chamber ICD's under faculty supervision</li> </ul>					X
<ul style="list-style-type: none"> <li>• Implant cardiac re-synchronization therapy systems under faculty supervision</li> </ul>					X
<ul style="list-style-type: none"> <li>• Perform pacemaker and ICD interrogations with the assistance of faculty or industry representatives, including troubleshooting of common pacemaker problems; eventually attain independence</li> </ul>			X		

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<ul style="list-style-type: none"> <li>• Recognize complications of pacemaker and ICD implantation including impatient-related and lead-related complications and device system infections</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Develop follow-up systems for patients with a permanent pacemaker or ICD</li> </ul>					X
<ul style="list-style-type: none"> <li>• Recognize normal sinus rhythm and variations of sinus rhythm</li> </ul>	X				
<ul style="list-style-type: none"> <li>• Recognize premature atrial, junctional and ventricular premature beats</li> </ul>	X				
<ul style="list-style-type: none"> <li>• Recognize atrial fibrillation and flutter</li> </ul>	X				
<ul style="list-style-type: none"> <li>• Recognize other re-entry supraventricular tachycardias including AV nodal re-entry tachycardia, accessory pathway tachycardias, sinus node re-entry tachycardia, and atrial re-entry tachycardia and re-entry junctional tachycardia</li> </ul>		X			

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<ul style="list-style-type: none"> <li>• Recognize automatic atrial tachycardia with and without block, multifocal atrial tachycardia and non-paroxysmal junctional tachycardia</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Recognize monomorphic and polymorphic ventricular tachycardias (all types), ventricular flutter and ventricular fibrillation</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Recognize asystole and agonal rhythm</li> </ul>	X				
<ul style="list-style-type: none"> <li>• Recognize 1° AV block, 2° AV block (types I and II) and 3° AV block (nodal and infra-nodal)</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Recognize left anterior and left posterior fascicular blocks, RBBB, LBBB, RBBB + left anterior or left posterior fascicular block, alternating bundle branch block and incomplete trifascicular block</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Recognize arrhythmias associated with sinus node dysfunction including sinus arrest, sinoatrial block and the bradycardia/tachycardia syndrome</li> </ul>		X			

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<ul style="list-style-type: none"> <li>• Recognize ectopic atrial, junctional and idioventricular rhythms, including accelerated versions of these rhythms</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Recognize the various forms of AV dissociation</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Recognize wandering pacemaker, reciprocal beats and reciprocal rhythms</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Recognize the electrocardiographic and intracardiac electrocardiographic manifestations of the pre-excitation syndrome</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Recognize inherited arrhythmia syndromes including the congenital long QT syndromes catecholaminergic polymorphic ventricular tachycardia the Brugada syndromes and the inherited short QT syndromes</li> </ul>				X	

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<ul style="list-style-type: none"> <li>• Manage each of the previously-mentioned cardiac arrhythmias and conduction disturbances including non-pharmacologic measures, pharmacotherapy, device therapy and ablation therapy</li> </ul>			X		
<ul style="list-style-type: none"> <li>• Recognize sudden cardiac arrest and sudden cardiac death</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Recognize and modify (when able) risk factors for sudden cardiac death</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Manage patients acutely during cardiac arrest. Perform BLS and ACLS in accordance with AHA guidelines</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Manage patients who were successfully resuscitated from cardiac arrest including in patients with acute myocardial infarction patients who suffer in-hospital cardiac arrest and patients who suffer out of hospital cardiac arrest</li> </ul>		X			
<ul style="list-style-type: none"> <li>• Provide long-term management to cardiac arrest survivors</li> </ul>		X			

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## CARDIAC ELECTROPHYSIOLOGY, ARRHYTHMIAS AND PACING

### Patient Care

Goals and Objectives	PF	EF	MF	LF	Aspirational
<ul style="list-style-type: none"><li>• Utilize methods to establish risk of cardiac arrest in various clinical settings</li></ul>		X			
<ul style="list-style-type: none"><li>• Select anti-arrhythmic drugs that may reduce sudden cardiac death risk</li></ul>			X		
<ul style="list-style-type: none"><li>• Identify patients who are candidates for an ICD based on their risk of cardiac arrest</li></ul>			X		
<ul style="list-style-type: none"><li>• Apply therapeutic strategies to specific groups of patients. Include those requiring secondary prevention of sudden cardiac death after survival of cardiac arrest, those with advanced heart disease requiring primary prevention and those without advanced heart disease, those without structural heart disease and the general population.</li></ul>			X		

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