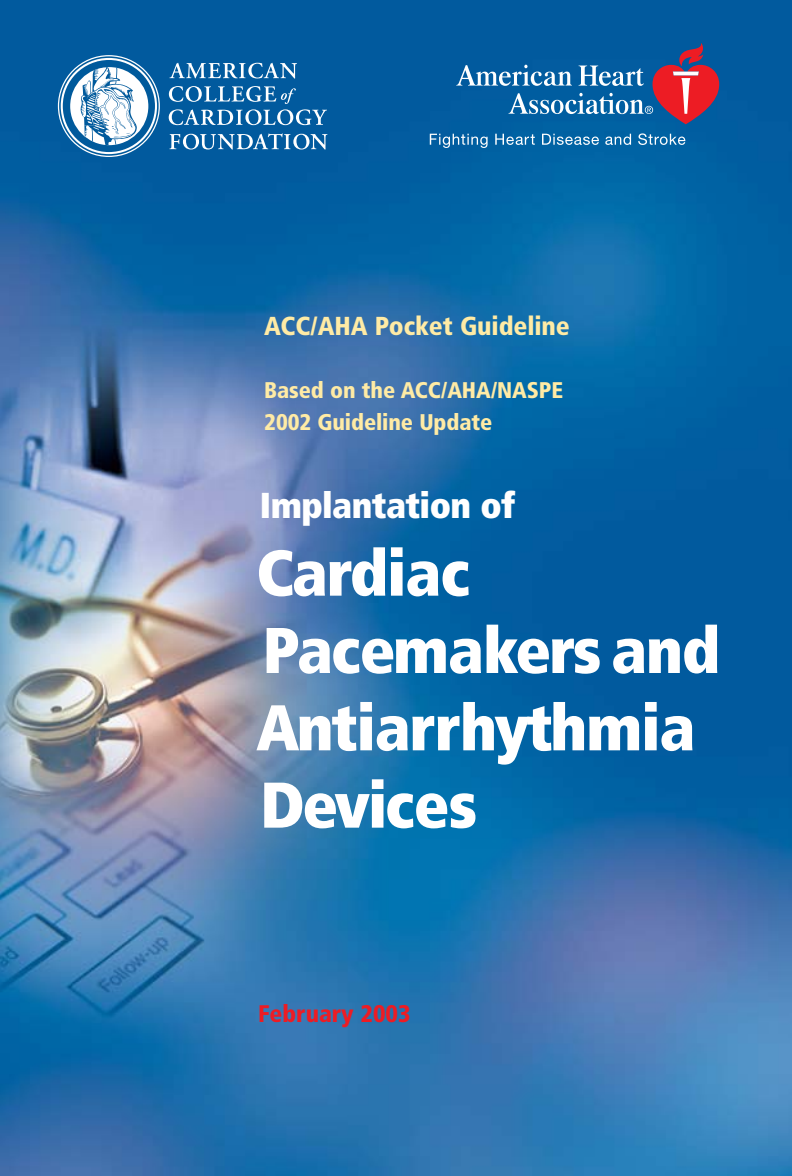
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Implantation of Cardiac Pacemakers and Antiarrhythmia Devices

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Contents

I. Introduction

The writing committee developed recommendations that are evidence-based whenever possible. The level of evidence for the various recommendations and the literature support appear in the full-text guideline. All of the listed recommendations for implantation of a device presume the absence of inciting causes that may be eliminated without detriment to the patient (eg, nonessential drug therapy). The treating physician must use clinical judgment and available data to decide whether a condition is persistent or when it can be expected to be transient. The term "symptomatic bradycardia" is used throughout the guidelines and is defined as a documented bradyarrhythmia that is directly responsible for the development of frank syncope or near-syncope, transient dizziness or light-headedness, and confusional states resulting from cerebral hypoperfusion attributable to slow heart rate. Fatigue, exercise intolerance, and frank congestive heart failure may also result from bradycardia.

Consistency with other previously published guidelines has been maintained except where evolution of device therapy necessitated the introduction of new recommendations or the modification of 1998 recommendations.

The recommendations for indications for device therapy are expressed in the standard ACC/AHA format:

Class I	Conditions for which there is evidence and/or general agreement that a given procedure or treatment is beneficial, useful, and effective.
Class II	Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of a procedure or treatment. **Class IIa** Weight of evidence/opinion is in favor of usefulness/efficacy. **Class IIb** Usefulness/efficacy is less well established by evidence/opinion.
Class III	Conditions for which there is evidence and/or general agreement that a procedure/treatment is not useful/effective and in some cases may be harmful.

II. Indications for Permanent Pacing

A. Pacing for Acquired Atrioventricular Block in Adults

Patients with abnormalities of atrioventricular (AV) conduction may be asymptomatic or may experience serious symptoms related to bradycardia, ventricular arrhythmias, or both. Decisions about the need for a pacemaker are necessarily influenced by the presence or absence of symptoms that are directly attributable to bradycardia.

Nonrandomized studies strongly suggest that permanent pacing improves survival in patients with third-degree AV block, particularly if syncope has occurred. Even when the ventricular rate is more than 40 bpm, permanent pacing should be strongly considered especially if the site of origin of the escape rhythm is infra-nodal. It is now recognized that marked first-degree AV block (PR greater than 0.30 seconds) can lead to symptoms even in the absence of higher degrees of AV conduction disturbance and may be associated with a "pseudo-pacemaker syndrome" because of close proximity of atrial systole to the preceding ventricular systole. Small uncontrolled trials have suggested some symptomatic and functional improvement with pacing in patients with PR intervals greater than 0.30 seconds, especially those with left ventricular (LV) dysfunction, some of whom may benefit from dual-chamber pacing with short AV delay.

Type I second-degree AV block is unlikely to progress to advanced AV block when the delay is within the AV node. However, with type II second-degree AV block (either intra- or infra-His), symptoms are frequent, prognosis is compromised, and progression to third-degree AV block is common. Permanent pacing in patients with the listed neuromuscular diseases and AV block of any degree should be strongly considered since progression of AV conduction disease in this setting is unpredictable.

Physiological AV block in the presence of supraventricular tachyarrhythmias is not an indication for pacemaker implantation except as specifically defined in the recommendations below. Similarly, neurally-mediated mechanisms in young patients with AV block should be assessed before proceeding with permanent pacing. Finally, permanent pacing for AV block after valve surgery follows a variable natural history; therefore, the decision for permanent pacing is at the physician's discretion.

Permanent Pacing

Recommendations for Permanent Pacing in Acquired Atrioventricular Block in Adults

Class I

1. Third-degree and advanced second-degree AV block at any anatomic level associated with any one of the following conditions:

a. Bradycardia with symptoms (including heart failure) presumed to be due to AV block.

b. Arrhythmias and other medical conditions that require drugs that result in symptomatic bradycardia.

c. Documented periods of asystole greater than or equal to 3.0 seconds or any escape rate less than 40 beats per minute (bpm) in awake, symptom-free patients.

d. After catheter ablation of the AV junction. There are no trials to assess outcome without pacing, and pacing is virtually always planned in this situation unless the operative procedure is AV junction modification.

e. Postoperative AV block that is not expected to resolve after cardiac surgery.

f. Neuromuscular diseases with AV block such as myotonic muscular dystrophy, Kearns-Sayre syndrome, Erb's dystrophy (limb-girdle), and peroneal muscular atrophy, with or without symptoms, because there may be unpredictable progression of AV conduction disease.

2. Second-degree AV block regardless of type or site of block, with associated symptomatic bradycardia.

Class IIa

1. Asymptomatic third-degree AV block at any anatomic site with average awake ventricular rates of 40 bpm or faster, especially if cardiomegaly or LV dysfunction is present.

2. Asymptomatic type II second-degree AV block with a narrow QRS. When type II second-degree AV block occurs with wide QRS, pacing becomes a Class I recommendation (see next section regarding Pacing for Chronic Bifascicular and Trifascicular Block).

3. Asymptomatic type I second-degree AV block at intra- or infra-His levels found at electrophysiologic study performed for other indications.

4. First- or second- degree AV block with symptoms similar to those of pacemaker syndrome.

Class IIb

1. Marked first-degree AV block (more than 0.30 seconds) in patients with LV dysfunction and symptoms of congestive heart failure in whom a shorter AV interval results in hemodynamic improvement, presumably by decreasing left atrial filling pressure.

2. Neuromuscular diseases such as myotonic muscular dystrophy, Kearns-Sayre syndrome, Erb's dystrophy (limb-girdle), and peroneal muscular atrophy with any degree of AV block (including first-degree AV block), with or without symptoms, because there may be unpredictable progression of AV conduction disease.

Class III

1. Asymptomatic first-degree AV block. (See "Pacing for Chronic Bifascicular and Trifascicular Block.")

2. Asymptomatic type I second-degree AV block at the supra-His (AV node) level or not known to be intra- or infra-Hisian.

3. AV block expected to resolve and unlikely to recur (eg, drug toxicity, Lyme disease, or during hypoxia in sleep apnea syndrome in absence of symptoms).

B. Pacing for Chronic Bifascicular and Trifascicular Block

Symptomatic advanced AV block that develops in patients with underlying bifascicular and trifascicular block (including patients with alternating [bilateral] bundle-branch block) is associated with a high mortality rate and a significant incidence of sudden death. However, the rate of progression of bifascicular block to third-degree AV block is slow. Syncope is common in patients with bifascicular block, and there is evidence that syncope in this setting is associated with an increased incidence of sudden cardiac death. Therefore, if the cause of syncope in the presence of bifascicular or trifascicular block cannot be determined with certainty, prophylactic permanent pacing is indicated. The PR and HV intervals have been identified as possible predictors of third-degree AV block and sudden death in the presence of underlying bifascicular block. However, the prolongation is often at the level of the AV node, and frequently there is no correlation between the PR and HV intervals and progression to third-degree AV block and sudden cardiac death. Some investigators have suggested that asymptomatic patients with bifascicular block and a prolonged HV interval (greater than 100 milliseconds) should be considered for permanent pacing, although the incidence of progression to third-degree AV block is low, even in the setting of prolonged HV interval.

Recommendations for Permanent Pacing in Chronic Bifascicular and Trifascicular Block

Class I

1. Intermittent third-degree AV block.
2. Type II second-degree AV block.
3. Alternating bundle-branch block.

Class IIa

1. Syncope not demonstrated to be due to AV block when other likely causes have been excluded, specifically ventricular tachycardia (VT).
2. Incidental finding at electrophysiologic study of markedly prolonged HV interval (greater than or equal to 100 milliseconds) in asymptomatic patients.
3. Incidental finding at electrophysiologic study of pacing-induced infra-His block that is not physiologic.

Class IIb

Neuromuscular diseases such as myotonic muscular dystrophy, Kearns-Sayre syndrome, Erb's dystrophy (limb-girdle), and peroneal muscular atrophy with any degree of fascicular block, with or without symptoms, because there may be unpredictable progression of AV conduction disease.

Class III

1. Fascicular block without AV block or symptoms.
2. Fascicular block with first-degree AV block without symptoms.

C. Pacing for Atrioventricular Block Associated With Acute Myocardial Infarction

The long-term prognosis of survivors of acute myocardial infarction (AMI) who develop AV block is related primarily to the extent of myocardial damage and the character of intraventricular conduction disturbances rather than the AV block itself. Indications for permanent pacing in this setting do not necessarily depend on the presence of symptoms. Patients with AMI who develop intraventricular conduction defects (with the exception of isolated left anterior fascicular block) have an unfavorable short- and long-term prognosis and an increased incidence of sudden death.The decision to implant a permanent pacemaker for AV or intraventricular conduction block complicating AMI will depend on the type of conduction disturbance,

location of the infarction, and relation of the electrical disturbance to infarct time. Thrombolytic therapy and primary percutaneous coronary interventions have decreased the incidence of high-grade AV block in AMI, but mortality remains high in this group of patients.

The impact of pre-existing bundle-branch block on mortality after AMI is uncertain. However, left bundle-branch block combined with advanced or third-degree AV block and right bundle-branch block combined with left anterior or left posterior fascicular block carry a particularly ominous prognosis.

Recommendations for Permanent Pacing After the Acute Phase of Myocardial Infarction*

Class I	1. Persistent second-degree AV block in the His-Purkinje system with bilateral bundle-branch block or third-degree AV block within or below the His-Purkinje system after AMI. 2. Transient advanced (second- or third-degree) infranodal AV block and associated bundle-branch block. If the site of block is uncertain, an electrophysiologic study may be necessary. 3. Persistent and symptomatic second- or third-degree AV block.
Class IIb	Persistent second- or third-degree AV block at the AV node level.
Class III	1. Transient AV block in the absence of intraventricular conduction defects. 2. Transient AV block in the presence of isolated left anterior fascicular block. 3. Acquired left anterior fascicular block in the absence of AV block. 4. Persistent first-degree AV block in the presence of bundle-branch block that is old or age indeterminate.

** These recommendations generally follow the ACC/AHA Guidelines for the Management of Patients with Acute Myocardial Infarction.*

D. Pacing in Sinus Node Dysfunction

Correlation of symptoms with arrhythmias resulting from sinus node dysfunction (eg, sinus bradycardia, sinus arrest, paroxysmal supraventricular tachycardia alternating with periods of bradycardia or even asystole) is essential in deciding whether a permanent pacemaker is indicated. This correlation may be difficult because of the intermittent nature of the episodes. Sinus node dysfunction may also express itself as chronotropic incompetence. Rate-responsive pacemakers can restore physiological heart rate responses during physical activity in this situation. Although permanent pacing will frequently relieve symptoms in patients with sinus node dysfunction, survival may not necessarily be improved. Whether dual-chamber pacing improves survival compared with ventricular pacing remains controversial.

Trained athletes may have a physiological sinus bradycardia of 40 to 50 bpm while awake and at rest and a sleeping heart rate as low as 30 bpm with sinus pauses producing asystolic intervals as long as 2.8 seconds. These findings are due to increased vagal tone and are not an indication for permanent pacing. In other patients, sinus pauses during sleep have uncertain significance and do not necessarily constitute an indication for pacing.

Recommendations for Permanent Pacing in Sinus Node Dysfunction

Class I	1. Sinus node dysfunction with documented symptomatic bradycardia, including frequent sinus pauses that produce symptoms. In some patients, bradycardia is iatrogenic and will occur as a consequence of essential long-term drug therapy of a type and dose for which there are no acceptable alternatives. 2. Symptomatic chronotropic incompetence.
Class IIa	1. Sinus node dysfunction occurring spontaneously or as a result of necessary drug therapy with heart rate less than 40 bpm when a clear association between significant symptoms consistent with bradycardia and the actual presence of bradycardia has not been documented. 2. Syncope of unexplained origin when major abnormalities of sinus node function are discovered or provoked in electrophysiologic studies.
Class IIb	In minimally symptomatic patients, chronic heart rate less than 40 bpm while awake.

Class III

1. Sinus node dysfunction in asymptomatic patients, including those in whom substantial sinus bradycardia (heart rate less than 40 bpm) is a consequence of long-term drug treatment.

2. Sinus node dysfunction in patients with symptoms suggestive of bradycardia that are clearly documented as not associated with a slow heart rate.

3. Sinus node dysfunction with symptomatic bradycardia due to nonessential drug therapy.

E. Prevention and Termination of Tachyarrhythmias by Pacing

Pacing can be useful in terminating a variety of tachyarrhythmias, including atrial flutter, paroxysmal re-entrant supraventricular tachycardia, and VT. Similarly, prevention of tachyarrhythmias by pacing has been demonstrated in several situations (eg, patients with the long QT syndrome and recurrent pause-dependent VT). In some patients with bradycardia-dependent atrial fibrillation, atrial pacing may reduce the frequency of recurrences. DDDR pacing reduced the risk of recurrent atrial fibrillation by 21% compared to VVIR pacing mode in the Mode Selection Trial (MOST Study). Dual-site and biatrial pacing are also actively being investigated as therapies for symptomatic drug-refractory atrial fibrillation.

Recommendations for Permanent Pacemakers That Automatically Detect and Pace to Terminate Tachycardias

Class IIa	Symptomatic recurrent supraventricular tachycardia that is reproducibly terminated by pacing in the unlikely event that catheter ablation and/or drugs fail to control the arrhythmia or produce intolerable side effects.
Class IIb	Recurrent supraventricular tachycardia or atrial flutter that is reproducibly terminated by pacing as an alternative to drug therapy or ablation.
Class III	1. Tachycardias frequently accelerated or converted to fibrillation by pacing. 2. The presence of accessory pathways with the capacity for rapid anterograde conduction whether or not the pathways participate in the mechanism of the tachycardia.

Pacing Recommendations to Prevent Tachycardia

Class I	Sustained pause-dependent VT, with or without prolonged QT, in which the efficacy of pacing is thoroughly documented.
Class IIa	High-risk patients with congenital long QT syndrome.
Class IIb	1. AV re-entrant or AV node re-entrant supraventricular tachycardia not responsive to medical or ablative therapy. 2. Prevention of symptomatic, drug-refractory, recurrent atrial fibrillation in patients with coexisting sinus node dysfunction.
Class III	1. Frequent or complex ventricular ectopic activity without sustained VT in the absence of the long QT syndrome. 2. Torsades de pointes VT due to reversible causes.

F. Pacing in Hypersensitive Carotid Sinus Syndrome and Neurocardiogenic Syncope

Hypersensitive carotid sinus syndrome may cause syncope or presyncope via both cardioinhibitory and vasodepressor reflexes. It is necessary to ascertain the relative contribution of each of these two components before concluding that permanent pacing is clinically indicated. Patients with symptoms due entirely to the cardioinhibitory response of carotid sinus stimulation can be effectively treated with permanent pacing. However, because up to 25% of patients also have an important vasodepressor component in their reflex response, pacing by itself may not be effective. Situational vasovagal syncope amenable to avoidance behavior does not constitute an indication for pacing. Elderly patients who sustain unexplained falls may have carotid sinus hypersensitivity in which case permanent pacing may reduce the risk of subsequent falls.

Recommendations for Permanent Pacing in Hypersensitive Carotid Sinus Syndrome and Neurocardiogenic Syncope

Class I	Recurrent syncope caused by carotid sinus stimulation; minimal carotid sinus pressure induces ventricular asystole of more than 3 seconds duration in the absence of any medication that depresses the sinus node or AV conduction.
Class IIa	1. Recurrent syncope without clear, provocative events and with a hypersensitive cardioinhibitory response. 2. Significantly symptomatic and recurrent neurocardiogenic syncope associated with bradycardia documented spontaneously or at the time of tilt-table testing.
Class III	1. A hyperactive cardioinhibitory response to carotid sinus stimulation in the absence of symptoms or in the presence of vague symptoms such as dizziness, lightheadedness, or both. 2. Recurrent syncope, lightheadedness, or dizziness in the absence of a hyperactive cardioinhibitory response. 3. Situational vasovagal syncope in which avoidance behavior is effective.

G. Pacing in Children and Adolescents

Permanent pacing in children or adolescents is generally indicated for (1) symptomatic sinus bradycardia, (2) the bradycardia-tachycardia syndromes, (3) congenital third-degree AV block, and (4) advanced second- or third-degree surgically-induced or acquired AV block. Important differences between indications for permanent pacing in children and adults include (1) age dependency of physiological heart rate and (2) impact of residual ventricular dysfunction and abnormal circulatory physiology after surgical palliation of complex congenital cardiac defects. Symptomatic bradycardia is an indication for pacemaker implantation, provided other causes of symptoms have been excluded.

The indications for permanent pacing in congenital third-degree AV block have evolved with some studies suggesting improved long-term survival and prevention of syncopal episodes in asymptomatic patients with congenital complete heart block who meet specific criteria. High-grade second- or third-degree AV block persisting for 7 to 14 days after cardiac surgery is an indication for permanent pacing. The need for permanent pacing in patients with transient postoperative AV block and residual bifascicular block has not been established, whereas patients with AV conduction that returns to normal have a favorable prognosis.

Recommendations for Permanent Pacing in Children, Adolescents, and Patients With Congenital Heart Disease

Class I

1. Advanced second- or third-degree AV block associated with symptomatic bradycardia, ventricular dysfunction, or low cardiac output.

2. Sinus node dysfunction with correlation of symptoms during age-inappropriate bradycardia. The definition of bradycardia varies with the patient's age and expected heart rate.

3. Postoperative advanced second- or third-degree AV block that is not expected to resolve or persists at least 7 days after cardiac surgery.

4. Congenital third-degree AV block with a wide QRS escape rhythm, complex ventricular ectopy, or ventricular dysfunction.

5. Congenital third-degree AV block in the infant with a ventricular rate less than 50 to 55 bpm or with congenital heart disease and a ventricular rate less than 70 bpm.

6. Sustained pause-dependent VT, with or without prolonged QT, in which the efficacy of pacing is thoroughly documented.

Class IIa

1. Bradycardia-tachycardia syndrome with the need for long-term antiarrhythmic treatment other than digitalis.

2. Congenital third-degree AV block beyond the first year of life with an average heart rate less than 50 bpm, abrupt pauses in ventricular rate that are two or three times the basic cycle length, or associated with symptoms due to chronotropic incompetence.

3. Long QT syndrome with 2:1 AV or third-degree AV block.

4. Asymptomatic sinus bradycardia in the child with complex congenital heart disease with resting heart rate less than 40 bpm or pauses in ventricular rate more than 3 seconds.

5. Patients with congenital heart disease and impaired hemodynamics due to sinus bradycardia or loss of AV synchrony.

Class IIb

1. Transient postoperative third-degree AV block that reverts to sinus rhythm with residual bifascicular block.

2. Congenital third-degree AV block in the asymptomatic infant, child, adolescent, or young adult with an acceptable rate, narrow QRS complex, and normal ventricular function.

3. Asymptomatic sinus bradycardia in the adolescent with congenital heart disease with resting heart rate less than 40 bpm or pauses in ventricular rate more than 3 seconds.

4. Neuromuscular diseases with any degree of AV block (including first-degree AV block), with or without symptoms, because there may be unpredictable progression of AV conduction disease.

Class III

1. Transient postoperative AV block with return of normal AV conduction.

2. Asymptomatic postoperative bifascicular block with or without first-degree AV block.

3. Asymptomatic type I second-degree AV block.

4. Asymptomatic sinus bradycardia in the adolescent when the longest RR interval is less than 3 seconds and minimum heart rate is more than 40 bpm.

H. Pacing in Hypertrophic or Dilated Cardiomyopathy and after Cardiac Transplantation

Nonrandomized studies in patients with severely symptomatic hypertrophic cardiomyopathy demonstrated that dual-chamber pacing with a short AV delay decreased the magnitude of LV outflow obstruction and improved symptoms.

However, subsequent studies suggested that a decrease in LV outflow gradient produced by temporary dual-chamber pacing may adversely affect ventricular filling and cardiac output. Finally, since recent randomized trials have yielded variable results, pacing indications for the treatment of outflow obstruction remain controversial.

Several nonrandomized trials of patients with symptomatic dilated cardiomyopathy refractory to medical therapy have reported limited improvement of symptoms with dual-chamber pacing with a short AV delay. However, at this time no long-term data are available, and there is no consensus for this indication. Biventricular pacing has been shown to confer significant clinical and structural cardiac improvement in patients with advanced heart failure, specific indices of LV dysfunction and prolonged QRS duration (usually left bundle-branch block).

Bradyarrhythmias after cardiac transplantation are common, occurring in 8% to 23% of patients and usually associated with sinus node dysfunction. Although some investigators have recommended more liberal use of cardiac pacing for persistent postoperative bradycardia, approximately 50% of these patients demonstrate significant improvement within 6 to 12 months after transplantation, and therefore long-term pacing is often unnecessary.

Patients with irreversible sinus node dysfunction or AV block with previously stated Class I indications should have permanent pacing.

Permanent Pacing

Pacing Recommendations for Hypertrophic Cardiomyopathy

Class I	Class I indications for sinus node dysfunction or AV block as previously described.
Class IIb	Medically refractory, symptomatic hypertrophic cardiomyopathy with significant resting or provoked LV outflow obstruction.
Class III	1. Patients who are asymptomatic or medically controlled. 2. Symptomatic patients without evidence of LV outflow obstruction.

Pacing Recommendations for Dilated Cardiomyopathy

Class I	Class I indications for sinus node dysfunction or AV block as previously described.
Class IIa	Biventricular pacing in medically refractory, symptomatic New York Heart Association (NYHA) class III or IV patients with idiopathic dilated or ischemic cardiomyopathy, prolonged QRS interval (greater than or equal to 130 milliseconds), LV end-diastolic diameter greater than or equal to 55 mm, and ejection fraction less than or equal to 35%.
Class III	1. Asymptomatic dilated cardiomyopathy. 2. Symptomatic dilated cardiomyopathy when patients are rendered symptomatic by drug therapy. 3. Symptomatic ischemic cardiomyopathy when the ischemia is amenable to intervention.

Pacing Recommendations After Cardiac Transplantation

Class I	Symptomatic bradyarrhythmias/chronotropic incompetence not expected to resolve and other Class I indications for permanent pacing.
Class IIb	Symptomatic bradyarrhythmias/chronotropic incompetence that, although transient, may persist for months and require intervention.
Class III	Asymptomatic bradyarrhythmias after cardiac transplantation.

I. Selection and Follow-up of Pacemaker Devices

Generator choices include single versus dual-chamber devices; unipolar versus bipolar configuration; presence of rate responsiveness and type of sensor used; advanced features such as special responses to sudden changes in rate, stored electrograms, atrial fibrillation suppression algorithms, and automatic capture verification; generator size; battery capacity; and cost. Lead choices include polarity, type of insulation material, active versus passive fixation mechanism, presence of steroid elution, and typical pacing impedance. Other factors that frequently influence the choice of a pacemaker system include the capabilities of the pacemaker programmer and local availability of technical support.

Current single-chamber pacemakers incorporate a number of programming features such as pacing mode, lower rate, pulse width and amplitude, sensitivity, and refractory period. There are many additional features of current dual-chamber pacemakers. The maximum tracking rate and AV delays are critical to optimization of the device for the individual patient. Rate responsive pacemakers require programmable features to regulate the sensor-driven pacing rate. These programmable parameters must be individualized for each patient.

Table 1 presents brief guidelines for selecting the appropriate pacemaker for the most commonly encountered indications for pacing. *Figure 1* depicts a decision tree for selecting a pacing system for a patient with AV block. *Figure 2* depicts a decision tree for selecting a pacing system for a patient with sinus node dysfunction. *Table 1* and *Figures 1* and *2* represent only a general guide for pacing for specific needs; many physicians will choose to implant a universally capable system with the expectation that other features may become necessary during the lifetime of the generator.

It has been suggested that less sophisticated devices, eg, single-chamber ventricular pacemakers or non-rate-responsive pacemakers, should be considered for elderly patients who require pacing. However, a large retrospective analysis of elderly Medicare patients suggested that dual-chamber pacing is associated with improved survival compared with ventricular pacing even after correction for confounding variables. On the basis of results of published randomized and nonrandomized trials, rate-responsive ventricular pacing and dual-chamber pacing appear to offer benefits over fixed-rate ventricular pacing with respect to quality of life.

The cost of a pacemaker increases with its degree of complexity and sophistication, and has been the subject of controversy. Optimal programming of output voltages, pulse widths, and AV delays can markedly decrease battery drain and prolong generator life by an average of 4 to 5 years compared to nominal settings.

After implantation of a pacemaker, careful follow-up and continuity of care are absolute requirements. Programming at implantation must be reviewed before the patient is discharged and further refined at subsequent follow-up visits as indicated by interrogation and testing. Frequency of follow-up is dictated by multiple factors, including other cardiovascular or medical problems managed by the physician involved, the age of the pacemaker, and the results of transtelephonic testing. Patients who are pacemaker dependent require more frequent clinical evaluations than those who are not. Follow-up evaluation usually includes assessment of battery status, pacing threshold and pulse width, sensing function, and lead integrity. The North American Society of Pacing and Electrophysiology and the Center for Medicaid and Medicare Services (previously HCFA) have published reports on antibradycardia pacemaker follow-up and guidelines *(Table 2)* for monitoring of patients with antibradycardia pacemakers, respectively.

Figure 1.

Selection of pacemaker systems for patients with atrioventricular block.

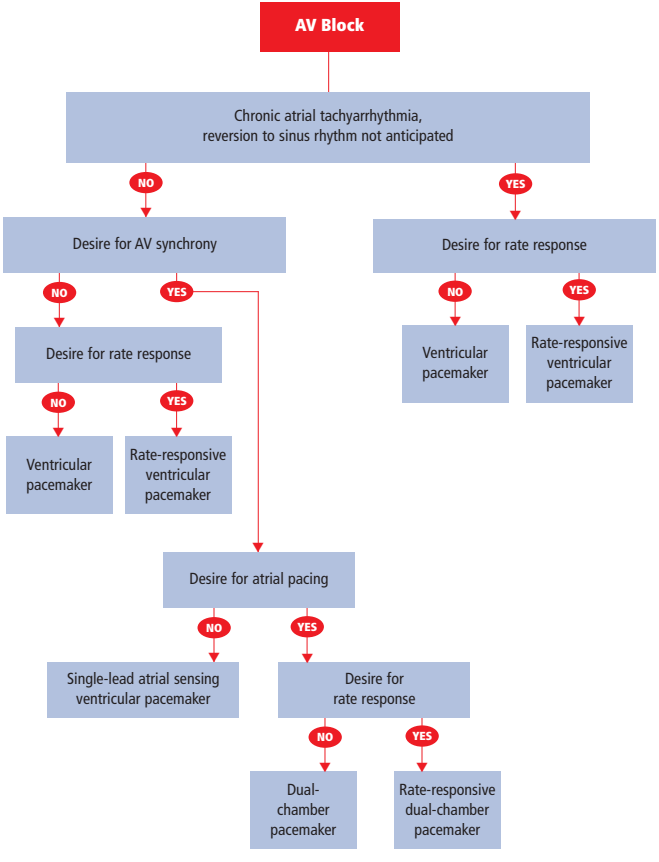
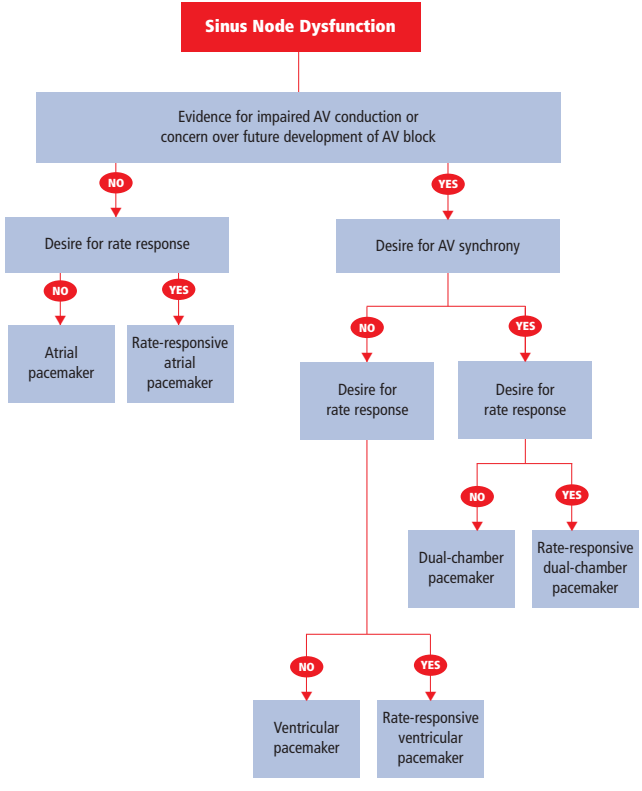


Figure 2.

Selection of Pacemaker Systems for Patients with Sinus Node Dysfunction



AV indicates atrioventricular.

Table 1.
Guidelines for Choice of Pacemaker Generator in Selected Indications for Pacing

	Sinus Node Dysfunction	AV Block	Neurally Mediated Syncope or Carotid Sinus Hypersensitivity
Single-chamber atrial pacemaker	■ No suspected abnormality of AV conduction and not at increased risk for future AV block ■ Maintenance of AV synchrony during pacing desired ■ Rate response available if desired	Not appropriate	Not appropriate
Single-chamber ventricular pacemaker	■ Maintenance of AV synchrony during pacing not necessary ■ Rate response available if desired	■ Chronic atrial fibrillation or other atrial tachyarrhythmia or maintenance of AV synchrony during pacing not necessary ■ Rate response available if desired	■ Chronic atrial fibrillation or other atrial tachyarrhythmia ■ Rate response available if desired
Dual-chamber pacemaker	■ AV synchrony during pacing desired ■ Suspected abnormality of AV conduction or increased risk for future AV block ■ Rate response available if desired	■ AV synchrony during pacing desired ■ Atrial pacing desired ■ Rate response available if desired	■ Sinus mechanism present ■ Rate response available if desired
Single-lead, atrial-sensing ventricular pacemaker	Not appropriate	■ Normal sinus node function and no need for atrial pacing ■ Desire to limit the number of pacemaker leads	Not appropriate

AV indicates atrioventricular.

Table 2.
HCFA Guidelines for Transtelephonic Monitoring (1984)

Guideline I

Months Pacemaker Implanted	1st	2nd to 36th	37th to Failure	
Single Chamber	Every 2 weeks	Every 8 weeks	Every 4 weeks	

Months Pacemaker Implanted	1st	2nd to 6th	7th to 36th	37th to Failure
Dual Chamber	Every 2 weeks	Every 4 weeks	Every 8 weeks	Every 4 weeks

Guideline II

Months Pacemaker Implanted	1st	2nd to 48th	49th to Failure	
Single Chamber	Every 2 weeks	Every 12 weeks	Every 4 weeks	

Months Pacemaker Implanted	1st	2nd to 30th	31st to 48th	49th to Failure
Dual Chamber	Every 2 weeks	Every 12 weeks	Every 8 weeks	Every 4 weeks

HCFA indicates Health Care Financing Administration.

III. Indications for Implantable Cardioverter-Defibrillator Therapy

Three major therapeutic options are currently available to reduce the frequency of or to prevent the occurrence of VT or ventricular fibrillation (VF) in patients at risk for these arrhythmias: (1) antiarrhythmic drug therapy; (2) VT ablation, either surgical or percutaneously with catheter techniques; and (3) implantation of an implantable cardioverter defibrillator (ICD).

Both early observational reports and subsequent prospective and sometimes randomized single-center and multicenter trials with long-term outcome data uniformly document sudden cardiac death recurrence rates of 1% to 2% annually after device implantation compared with recurrences of 15% to 25% without device therapy. Patients with impaired LV function have reduced survival rates compared with those with more preserved ejection fractions, but both populations appear to derive a significant survival benefit from ICD implantation. The addition of an antiarrhythmic drug or the application of ablative therapy for selected patients with ICDs may further improve their quality of life by reducing recurrence of arrhythmias and the need for defibrillation.

Patients with coronary artery disease constitute the majority of those receiving ICDs with improved outcomes documented in the literature. Optimal anti-ischemic therapy including (when possible) a beta blocker should be used concomitantly in patients with an ICD. Furthermore, as for all patients with left ventricular dysfunction, heart failure management must also be optimized.

Patients with idiopathic dilated cardiomyopathy have a high mortality rate within 2 years of diagnosis, and approximately half die suddenly and unexpectedly. About 10% of patients receiving ICDs have this disease. ICD therapy has also been used successfully in selected patients with the long QT syndrome, hypertrophic cardiomyopathy, arrhythmogenic right ventricular dysplasia, idiopathic VF, the Brugada syndrome, and syncope with inducible sustained VT.

Pediatric patients represent more than 1% of persons with ICDs. Although sudden cardiac death is uncommon in childhood, it is mainly associated with three forms of heart disease: (1) congenital heart disease (tetralogy of Fallot, transposition of the great arteries,

and others), (2) cardiomyopathy (hypertrophic or dilated), and (3) primary electrical disease (long QT syndrome and others). A family history of sudden cardiac death may be an important indication for implantation of an ICD in a pediatric patient with these conditions.

ICD therapy has been shown to be effective in the primary prevention of sudden cardiac death in patients with coronary artery disease who have sustained a myocardial infarction and have a markedly reduced left ventricular ejection fraction with or without associated non-sustained VT.

Empiric amiodarone therapy has shown inconsistent survival benefit, although a reported meta-analysis suggests that total mortality may be reduced when amiodarone is compared with other medical therapies.

Recommendations for ICD Therapy

Class I

1. Cardiac arrest due to VF or VT not due to a transient or reversible cause.

2. Spontaneous sustained VT in association with structural heart disease.

3. Syncope of undetermined origin with clinically relevant, hemodynamically significant sustained VT or VF induced at electrophysiologic study when drug therapy is ineffective, not tolerated, or not preferred.

4. Nonsustained VT in patients with coronary disease, prior myocardial infarction, LV dysfunction, and inducible VF or sustained VT at electrophysiologic study that is not suppressible by a Class I antiarrhythmic drug.

5. Spontaneous sustained VT in patients without structural heart disease not amenable to other treatments.

Class IIa

Patients with left ventricular ejection fraction of less than or equal to 30% at least 1 month post myocardial infarction and 3 months post coronary artery revascularization surgery.

Class IIb

1. Cardiac arrest presumed to be due to VF when electrophysiologic testing is precluded by other medical conditions.

2. Severe symptoms (eg, syncope) attributable to ventricular tachyarrhythmias in patients awaiting cardiac transplantation.

3. Familial or inherited conditions with a high risk for life-threatening ventricular tachyarrhythmias such as long QT syndrome or hypertrophic cardiomyopathy.

4. Nonsustained VT with coronary artery disease, prior MI, and LV dysfunction, and inducible sustained VT or VF at electrophysiologic study.

5. Recurrent syncope of undetermined origin in the presence of ventricular dysfunction and inducible ventricular arrhythmias at electrophysiologic study when other causes of syncope have been excluded.

6. Syncope of unexplained origin or family history of unexplained sudden cardiac death in association with typical or atypical right bundle-branch block and ST-segment elevation (Brugada syndrome).

7. Syncope in patients with advanced structural heart disease in whom thorough invasive and noninvasive investigations have failed to define a cause.

Class III

1. Syncope of undetermined cause in a patient without inducible ventricular tachyarrhythmias and without structural heart disease.

2. Incessant VT or VF.

3. VF or VT resulting from arrhythmias amenable to surgical or catheter ablation; for example, atrial arrhythmias associated with the Wolff-Parkinson-White syndrome, right ventricular outflow tract VT, idiopathic left ventricular tachycardia, or fascicular VT.

4. Ventricular tachyarrhythmias due to a transient or reversible disorder (eg, AMI, electrolyte imbalance, drugs, or trauma) when correction of the disorder is considered feasible and likely to substantially reduce the risk of recurrent arrhythmia.

ICD Therapy

5. Significant psychiatric illnesses that may be aggravated by device implantation or may preclude systematic follow-up.

6. Terminal illnesses with projected life expectancy less than 6 months.

7. Patients with coronary artery disease with LV dysfunction and prolonged QRS duration in the absence of spontaneous or inducible sustained or nonsustained VT who are undergoing coronary bypass surgery.

8. NYHA Class IV drug-refractory congestive heart failure in patients who are not candidates for cardiac transplantation.