

Cigna Medical Coverage Policies – Radiology Cardiac Implantable Device (CRID)

Effective October 16, 2020



Instructions for use

The following coverage policy applies to health benefit plans administered by Cigna. Coverage policies are intended to provide guidance in interpreting certain standard Cigna benefit plans and are used by medical directors and other health care professionals in making medical necessity and other coverage determinations. Please note the terms of a customer's particular benefit plan document may differ significantly from the standard benefit plans upon which these coverage policies are based. For example, a customer's benefit plan document may contain a specific exclusion related to a topic addressed in a coverage policy.

In the event of a conflict, a customer's benefit plan document always supersedes the information in the coverage policy. In the absence of federal or state coverage mandates, benefits are ultimately determined by the terms of the applicable benefit plan document. Coverage determinations in each specific instance require consideration of:

1. The terms of the applicable benefit plan document in effect on the date of service
2. Any applicable laws and regulations
3. Any relevant collateral source materials including coverage policies
4. The specific facts of the particular situation

Coverage policies relate exclusively to the administration of health benefit plans. Coverage policies are not recommendations for treatment and should never be used as treatment guidelines.

This evidence-based medical coverage policy has been developed by eviCore, Inc. Some information in this coverage policy may not apply to all benefit plans administered by Cigna.

These guidelines include procedures eviCore does not review for Cigna. Please refer to the [Cigna CPT code list](#) for the current list of high-tech imaging procedures that eviCore reviews for Cigna.

CPT® (Current Procedural Terminology) is a registered trademark of the American Medical Association (AMA). CPT® five digit codes, nomenclature and other data are copyright 2017 American Medical Association. All Rights Reserved. No fee schedules, basic units, relative values or related listings are included in the CPT® book. AMA does not directly or indirectly practice medicine or dispense medical services. AMA assumes no liability for the data contained herein or not contained herein.

Cardiac Implantable Device (CRID) Guidelines	
Abbreviations	3
Glossary	4
Preface to the eviCore CRID Guidelines	5
CRID-1: General Information	9
CRID-2: Definite Indications for ICD Implantation	13
CRID-3: Reasonable Indications for ICD Implantation	16
CRID-4: ICD Implantation — Non-Indications	19
CRID-5: Indications for Cardiac Resynchronization Therapy (CRT)-D Implantation	22
CRID-6: Cardiac Resynchronization Therapy (CRT)-D Implantation — Non-Indications	25
CRID-7: Definite Indications for Permanent Pacemaker Implantation	27
CRID-8: Reasonable Indications for Permanent Pacemaker Implantation	30
CRID-9: Permanent Pacemaker Implantation	33
CRID-10: Cardiac Resynchronization Therapy (CRT)-P	35
CRID-11: Leadless Implantable Devices	37

Abbreviations

ACE inhibitor	angiotensin-converting enzyme inhibitor
AMI	acute myocardial infarction
ARVC	arrhythmogenic right ventricular cardiomyopathy
CC	complications/comorbid conditions
CHF	congestive heart failure
CM	cardiomyopathy
CRT	cardiac resynchronization therapy
EP	electrophysiology
ICD	implantable cardioverter defibrillator
LV	left ventricular
LVEF	left ventricular ejection fraction
MCC	major complications/comorbid conditions
MI	myocardial infarction
NCCM	non-compaction cardiomyopathy
NYHA	New York Heart Association functional classification
VF	ventricular fibrillation
VT	ventricular tachycardia

Glossary

Class	NYHA Heart Failure Definitions
I	No symptoms and no limitation in ordinary physical activity, e.g. shortness of breath when walking, climbing stairs etc.
II	Mild symptoms (mild shortness of breath and/or angina) and slight limitation during ordinary activity.
III	Marked limitation in activity due to symptoms, even during less-than-ordinary activity, e.g. walking short distances (20–100 m). Comfortable only at rest.
IV	Severe limitations. Experiences symptoms even while at rest. Mostly bedbound patients
<p>Abnormal blood pressure response to exercise: Flat response/failure to augment; rise then fall during exercise; vasoactive cardiovascular drugs may result in an abnormal blood pressure response to exercise</p>	
<p>Non-Sustained Ventricular Tachycardia (NSVT): Three or more consecutive ventricular beats at a rate of greater than 120 beats/min with a duration of less than 30 seconds</p>	
<p>Incessant VT: Frequent recurrences of ongoing hemodynamically stable VT</p>	
<p>Long QT Syndrome (LQTS): A congenital disorder characterized by a prolongation of the QT interval on ECG and a propensity to ventricular tachyarrhythmias, which may lead to syncope, cardiac arrest, or sudden death.</p> <p>The QT interval on the ECG, measured from the beginning of the QRS complex to the end of the T wave, represents the duration of activation and recovery of the ventricular myocardium. QT intervals corrected for heart rate (QTc) longer than 0.44 seconds are generally considered abnormal, though a normal QTc can be more prolonged in females (up to 0.46 sec). The Bazett formula is the formula most commonly used to calculate the QTc, as follows: $QTc = QT / \sqrt{RR}$ (in seconds).</p>	
<p>Optimal Medical Therapy: Three months of heart failure medications in maximally titrated doses as tolerated. These include beta blockers, ACE inhibitors or angiotensin II receptor blocker, and diuretics.</p>	
<p>Structural Heart Disease: A structural or functional abnormality of the heart, or of the blood vessels supplying the heart, that impairs its normal functioning.</p>	
<p>Non-Compaction Cardiomyopathy: A rare congenital cardiomyopathy that affects children and adults. It results from the failure of myocardial development during embryogenesis. It is also called spongiform cardiomyopathy. Symptoms are often a result of a poor pumping performance by the heart. The disease can be associated with other problems with the heart and the body.</p>	

Preface to the eviCore CRID Guidelines

CRID Preface-1: Guideline Development	6
CRID Preface-2: Benefits, Coverage Policies, and Eligibility Issues	7
CRID Preface-3: Clinical Information	7
CRID Preface-4: References	7
CRID Preface-5: Copyright Information	8
CRID Preface-6: Trademarks	8

CRID Preface-1: Guideline Development

- The eviCore evidence-based, proprietary clinical guidelines evaluate a range of advanced imaging and procedures, including CT, MRI, PET, and Radiation Oncology, Sleep Studies, and Cardiac and Spine interventions.
- eviCore healthcare reserves the right to change and update the guidelines. The guidelines undergo a formal review annually. eviCore's guidelines are based upon major national and international association and society guidelines and criteria, peer-reviewed literature, major treatises, and input from health plans, practicing academic and community-based physicians
- These guidelines are not intended to supersede or replace sound medical judgment, but instead should facilitate the identification of the most appropriate imaging procedure, given the patient's clinical condition. These guidelines are written to cover medical conditions as experienced by the majority of patients. However, these guidelines may not be applicable in certain clinical circumstances, and physician judgment can override the guidelines
- Clinical decisions, including treatment decisions, are the responsibility of the patient and his/her provider. Clinicians are expected to use independent medical judgment which takes into account the clinical circumstances to determine patient management decisions
- eviCore supports the Choosing Wisely® initiative (www.choosingwisely.org) by the American Board of Internal Medicine (ABIM) Foundation and many national physician organizations, to reduce the overuse of diagnostic tests that are low value, no value, or whose risks are greater than the benefits
- eviCore's guidelines are based upon expert consensus and analysis reported by the following specialty societies, publications, studies and trials:
 - ◆ The American College of Cardiology (ACC)
 - ◆ The American Heart Association (AHA)
 - ◆ The Heart Rhythm Society (HRS)
 - ◆ The Multicenter Automatic Defibrillator Implantation Trial (MADIT/MADIT-2)
 - ◆ The Multicenter Unsustained Tachycardia Trial (MUSTT)
 - ◆ The Defibrillator in Acute Myocardial Infarction Trial (DINAMIT)
 - ◆ The Resynchronization/defibrillation for Ambulatory Heart Failure Trial (RAFT)
 - ◆ The Sudden Cardiac Death in Heart Failure Trial (SCD-HeFT)
 - ◆ The Resynchronization Reverses Remodeling in Systolic Left Ventricular Dysfunction trial (REVERSE)
 - ◆ Immediate Risk Stratification Improves Survival trial (IRIS)
 - ◆ The Comparison of Medical Therapy, Pacing, and Defibrillation in Heart Failure trial (COMPANION)
 - ◆ The Antiarrhythmic Versus Implantable Defibrillators trial (AVID)
 - ◆ The Canadian Implantable Defibrillator Study (CIDS)
 - ◆ The Cardiac Arrest Study Hamburg (CASH)

CRID Preface-2: Benefits, Coverage Policies, and Eligibility Issues

- Benefits, coverage policies, and eligibility issues pertaining to each Health Plan may take precedence over eviCore's guidelines. Providers are urged to obtain written instructions and requirements directly from each payer
- Medicare Coverage Policies
 - ◆ For Medicare and Medicare Advantage enrollees, the coverage policies of CMS (Centers for Medicare and Medicaid Services) may take precedence over eviCore's guidelines
 - ◆ Payers may choose to adopt other evidence-based guidelines (such as eviCore's guidelines) rather than using Local Coverage Determinations and other Medicare coverage policy
- Investigational and Experimental Studies
 - ◆ Certain imaging studies described in these guidelines are considered investigational by various payers, and their coverage policies may take precedence over eviCore's guidelines
- Clinical and Research Trials
 - ◆ Similar to investigational and experimental studies, clinical trial imaging requests will be considered to determine whether they meet health plan coverage and eviCore's evidence-based guidelines
- State and federal legislations may need to be considered in the review of advanced imaging requests

CRID Preface-3: Clinical Information

- The philosophy behind eviCore guidelines entails using an evidence-based approach to determine the most appropriate procedure for each individual, at the most appropriate time in the diagnostic and treatment cycle
- Procedures should be requested after initial consultation and physician treatment planning, and following full counseling of the individual
- Current clinical information, which may include history, physical examination, symptoms, laboratory results, and imaging reports, are necessary for determining the medical necessity of implantable cardioverter defibrillator (ICD) devices and cardiac resynchronization therapy (CRT-D)
- The information provided to eviCore should have clinical relevance to the request
- If the information provided makes no reference to the potential indication for the request, then the medical necessity for the procedure(s) cannot be supported

CRID Preface-4: References

- References are available at the end of the guidelines

CRID Preface-5: Copyright Information

- ©2018 eviCore healthcare. All rights reserved. No part of these materials may be changed, reproduced, or transmitted in any form or by any means, electronic or mechanical, including photocopying or recording, or in any information storage or retrieval system, without the prior express written permission of eviCore.

CRID Preface-6: Trademarks

- **CPT® (Current Procedural Terminology)** is a registered trademark of the American Medical Association (AMA). **CPT®** five digit codes, nomenclature and other data are copyright 2017 American Medical Association. All Rights Reserved. No fee schedules, basic units, relative values or related listings are included in the CPT® book. AMA does not directly or indirectly practice medicine or dispense medical services. AMA assumes no liability for the data contained herein or not contained herein.

CRID-1: General Information

CRID-1.0: General Guidelines	10
CRID-1.1: Procedure Codes	10
CRID-1.2: Removal and replacement	12

CRID-1.0: General Guidelines

- Current clinical information, which may include history, physical examination, symptoms, laboratory results, and imaging reports, are necessary for determining the medical necessity of implantable cardioverter defibrillator (ICD) devices and cardiac resynchronization therapy (CRT-D)
- The information provided to eviCore should have clinical relevance to the request
- If the information provided makes no reference to the potential indication for the request, then the medical necessity for the procedure(s) cannot be supported

CRID-1.1: Procedure Codes

- The CPT® code set **33202-33249** includes the various Pacemaker and Defibrillator procedures including the insertion, replacement and removal of the leads. Some of the codes apply to both the pacemaker and the defibrillator. Codes are included for informational purposes only and any given code's inclusion on this list does not necessarily indicate prior authorization is required. Pre-authorization requirements vary by health plan.

CPT®	DESCRIPTION
33206	Insertion of new or replacement of permanent pacemaker with transvenous electrode(s); atrial
33207	Insertion of new or replacement of permanent pacemaker with transvenous electrode(s); ventricular
33208	Insertion of new or replacement of permanent pacemaker with transvenous electrode(s); atrial and ventricular
33212	Insertion of pacemaker pulse generator only; single existing single lead
33213	Insertion of pacemaker pulse generator only; with existing dual leads
33214	Upgrade of implanted pacemaker system, conversion of single chamber system to dual chamber system (includes removal of previously placed pulse generator, testing of existing lead, insertion of new lead, insertion of new pulse generator)
33227	Removal of permanent pacemaker pulse generator with replacement of pacemaker pulse generator; single lead system
33228	Removal of permanent pacemaker pulse generator with replacement of pacemaker pulse generator; dual lead system
33221	Insertion of pacemaker pulse generator only; with existing multiple leads
33224	Insertion of pacing electrode, cardiac venous system, for left ventricular pacing, with attachment to previously placed pacemaker or pacing cardioverter-defibrillator pulse generator
33225	Insertion of pacing electrode, cardiac venous system, for left ventricular pacing, at time of insertion of pacing cardioverter-defibrillator pulse generator (including upgrade to dual chamber system and pocket revision)
33229	Removal of permanent pacemaker pulse generator with replacement of pacemaker pulse generator; multiple lead system
33230	Insertion of pacing cardioverter-defibrillator pulse generator only; with existing dual leads
33231	Insertion of pacing cardioverter-defibrillator pulse generator only; with existing multiple leads

33240	Insertion of pacing cardioverter-defibrillator pulse generator only; with existing single leads
33249	Insertion or replacement of permanent pacing cardioverter-defibrillator system with transvenous lead(s), single or dual chamber
33262	Removal of pacing cardioverter-defibrillator pulse generator with replacement of pacing cardioverter-defibrillator pulse generator; single lead system
33263	Removal of pacing cardioverter-defibrillator pulse generator with replacement of pacing cardioverter-defibrillator pulse generator; dual lead system
33264	Removal of pacing cardioverter-defibrillator pulse generator with replacement of pacing cardioverter-defibrillator pulse generator; multiple lead system
33270	Insertion or replacement of permanent subcutaneous implantable defibrillator system, with subcutaneous electrode, including defibrillation threshold evaluation, induction of arrhythmia, evaluation of sensing for arrhythmia termination, and programming or reprogramming of sensing or therapeutic parameters when performed
33271	Insertion of subcutaneous implantable defibrillator electrode
33274	Transcatheter insertion or replacement of permanent leadless pacemaker, right ventricular, including imaging guidance (e.g., fluoroscopy, venous ultrasound, ventriculography, femoral venography) and device evaluation (e.g., interrogation or programming), when performed
33275	Transcatheter removal of permanent leadless pacemaker, right ventricular
33289	Transcatheter implantation of wireless pulmonary artery pressure sensor for long-term hemodynamic monitoring, including deployment and calibration of the sensor, right heart catheterization, selective pulmonary catheterization, radiological supervision and interpretation, and pulmonary artery angiography, when performed
0515T	Insertion of wireless cardiac stimulator for left ventricular pacing, including device interrogation and programming, and imaging supervision and interpretation, when performed; complete system (includes electrode and generator [transmitter and battery])
0516T	Insertion of wireless cardiac stimulator for left ventricular pacing, including device interrogation and programming, and imaging supervision and interpretation, when performed; electrode only
0517T	Insertion of wireless cardiac stimulator for left ventricular pacing, including device interrogation and programming, and imaging supervision and interpretation, when performed; pulse generator component(s) (battery and/or transmitter) only
0519T	Removal and replacement of wireless cardiac stimulator for left ventricular pacing; pulse generator component(s) (battery and/or transmitter)
0520T	Removal and replacement of wireless cardiac stimulator for left ventricular pacing; pulse generator component(s) (battery and/or transmitter), including placement of a new electrode
0571T	Insertion or replacement of implantable cardioverter-defibrillator system with substernal electrode(s), including all imaging guidance and electrophysiological evaluation (includes defibrillation threshold evaluation, induction of arrhythmia, evaluation of sensing for arrhythmia termination, and programming or reprogramming of sensing or therapeutic parameters), when performed
0572T	Insertion of substernal implantable defibrillator electrode

CRID-1.2: Removal and replacement

- Generator replacement (**CPT® 33227, 33228, 33229, 33262, 33263, 33264**) with a same or similar device is indicated when:
 - ◆ Interrogation shows device is nearing Elective Replacement Indicator (ERI) or End of Life (EOL).
 - ◆ Interrogation report documents the device is not functioning correctly and requires replacement.

CRID-2: Definite Indications for ICD Implantation

CRID-2.1: Survivors of Cardiac Arrest	14
CRID-2.2: Structural Heart Disease with Sustained VT	14
CRID-2.3: Syncope of Undetermined Origin and Positive EP Study	14
CRID-2.4: Unexplained Syncope	14
CRID-2.5: Ischemic Cardiomyopathy	14
CRID-2.6: Nonischemic Dilated Cardiomyopathy (DCM)	15

CRID-2.1: Survivors of Cardiac Arrest

- ICD implantation is indicated in individuals who are survivors of cardiac arrest due to ventricular tachycardia (VT) or ventricular fibrillation (VF) after evaluation has excluded any completely reversible causes

CRID-2.2: Structural Heart Disease with Sustained VT

- ICD implantation is indicated in individuals with structural heart disease (such as prior myocardial infarction (MI), congenital heart disease, and/or ventricular dysfunction) and spontaneous, sustained VT (greater than 30 seconds), whether hemodynamically stable or unstable

CRID-2.3: Syncope of Undetermined Origin and Positive EP Study

- ICD implantation is indicated in individuals with syncope of undetermined origin who have clinically relevant, hemodynamically significant sustained VT or VF induced at electrophysiology (EP) study

CRID-2.4: Unexplained Syncope

- ICD implantation is indicated in individuals with unexplained syncope, significant left ventricular (LV) dysfunction (LV ejection fraction less than 50%), and structural heart disease such as prior myocardial infarction (MI), congenital heart disease, and/or ventricular dysfunction

CRID-2.5: Ischemic Cardiomyopathy

- ICD implantation is indicated in individuals with **any** of the following:
 - ◆ LV dysfunction due to prior myocardial infarction (MI) and **all** of the following
 - LV ejection fraction less than or equal to 35%
 - At least 40 days post-MI
 - Are NYHA functional Class II or III
 - Are on optimal medical therapy, defined as 3 months of maximally titrated doses as tolerated of an ACE inhibitor/angiotensin II receptor blocker, beta-blocker, and diuretic
 - ◆ LV dysfunction due to prior MI and **all** of the following
 - LV ejection fraction less than or equal to 30%
 - At least 40 days post-MI
 - Are NYHA functional Class I
 - ◆ Have non-sustained VT due to prior MI and **all** of the following
 - LV ejection fraction less than or equal to 40%
 - Have inducible VF or sustained VT at EP study performed at least 96 hours after revascularization or MI
 - If the ejection fraction was less than 35% prior to the most recent MI then the 40 day waiting period can be waived

CRID-2.6: Nonischemic Dilated Cardiomyopathy (DCM)

- ICD implantation is indicated in individuals with nonischemic dilated cardiomyopathy who have all of the following:
 - ◆ LV ejection fraction less than or equal to 35%
 - ◆ NYHA Class II or III CHF
 - ◆ Are on optimal medical therapy
 - Optimal medical therapy is defined as 3 months of maximally titrated doses as tolerated of an ACE inhibitor/angiotensin II receptor blocker, beta-blocker, and, if needed, a diuretic
- Trials assessing ICD therapy in primary prophylaxis in DCM have not generally included asymptomatic, NYHA functional Class I patients.

CRID-3: Reasonable Indications for ICD Implantation

CRID-3.1: General Considerations	17
CRID-3.2: Sustained Ventricular Tachycardia with Normal LV Function	17
CRID-3.3: Cardiomyopathy	17
CRID-3.4: Long QT Syndrome	17
CRID-3.5: Brugada Syndrome	18
CRID-3.6: Catecholaminergic Polymorphic Ventricular Tachycardia	18
CRID-3.7: Other Indications	18

CRID-3.1: General Considerations

- For the “reasonable” or “considered” indications listed in this CRID-3 guideline, consensus opinion is less clear about the use of ICD implantation in these settings. Limited evidence suggests that ICD placement may be reasonable or may be considered; this category includes VF or hypotensive VT events where pharmaceutical or ablative techniques are indicated but the results of treatment are too unpredictable to withhold ICD implantation.

CRID-3.2: Sustained Ventricular Tachycardia with Normal LV Function

- ICD implantation is reasonable for individuals with sustained VT and normal or near-normal ventricular function

CRID-3.3: Cardiomyopathy

- Cardiomyopathy due to Hypertrophic Cardiomyopathy:
 - ◆ ICD implantation is reasonable for individuals with hypertrophic cardiomyopathy who have one or more risk factors for sudden cardiac death
 - Risk factors for sudden cardiac death include the following:
 - Unheralded syncope
 - Family history of sudden death
 - Septal wall thickness of greater than or equal to 30 mm
 - Abnormal blood pressure response to exercise
 - Nonsustained VT (< 30 seconds)
- Cardiomyopathy due to Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC):
 - ◆ ICD implantation is reasonable for individuals with ARVC who have one or more risk factors for sudden cardiac death
 - Risk factors for sudden cardiac death include the following:
 - Unheralded syncope
 - Family history of sudden death
 - Nonsustained VT(< 30 seconds)
 - Clinical signs of RV failure

CRID-3.4: Long QT Syndrome

- ICD implantation is reasonable in Long-QT Syndrome in the following settings:
 - ◆ Syncope and/or VT while receiving beta-blockers or if beta-blockers are contraindicated
 - ◆ Asymptomatic with other risk factors for sudden cardiac death
 - Risk factors for sudden cardiac death include the following:
 - QTc greater than 500 msec **or**
 - LQT 2 or 3
 - Family history of sudden death

CRID-3.5: Brugada Syndrome

- ICD implantation is reasonable for individuals with Brugada Syndrome who have had the following:
 - ◆ Syncope **or**
 - ◆ Documented or inducible VT or VF

CRID-3.6: Catecholaminergic Polymorphic Ventricular Tachycardia

- ICD implantation is reasonable for individuals with catecholaminergic polymorphic VT who have syncope and/or documented sustained VT while receiving beta-blockers

CRID-3.7: Other Indications

- ICD implantation is reasonable, regardless of LV ejection fraction measurement, for individuals with:
 - ◆ Cardiac sarcoidosis
 - ◆ Giant cell myocarditis
 - ◆ Chagas disease
- LV non compaction
 - ◆ ICD implantation should be considered for the primary prevention of sudden cardiac death due to malignant ventricular arrhythmias in individuals with non-compaction cardiomyopathy and impaired LV function (LV ejection fraction less than 50%)
 - ICD implantation is also indicated for normal LV function (LVEF greater than 50%) primary prevention cases with positive family history of sudden cardiac death. This exception is due to the presence of sarcomeric gene mutations reported in non-compaction cardiomyopathy
- ICD implantation may be considered in affected individuals with a familial cardiomyopathy associated with sudden death

CRID-4: ICD Implantation—Non-Indications

CRID-4.1: Ischemic Cardiomyopathy	20
CRID-4.2: NYHA Class IV CHF	20
CRID-4.3: Limited Life Expectancy	20
CRID-4.4: Incessant VT or VF	20
CRID-4.5: Psychiatric Conditions	20
CRID-4.6: Reversible Cause of VT/VF	20
CRID-4.7: Ablation Candidate, No Structural Heart Disease	21
CRID-4.8: Substernal implantable cardioverter-defibrillator	21

CRID-4.1: Ischemic Cardiomyopathy

- ICD implantation is **not** indicated in individuals who have had a myocardial infarction within the past 40 days or who have had coronary revascularization within the past 90 days **unless** the following applies:
 - ◆ A separate indication for permanent pacemaker implantation exists (thus preventing a likely repeat procedure for an upgraded device in the near future)

CRID-4.2: NYHA Class IV CHF

- ICD implantation is **not** indicated for individuals with NYHA functional class IV symptoms **unless** one of the following applies:
 - ◆ It is a CRT-D device meeting the indications for CRT-D implantation listed in **CRID-5.1: Sinus Rhythm, Dilated Cardiomyopathy with NYHA Class II, III, or IV Congestive Heart Failure (CHF)**
 - ◆ The individual is awaiting heart transplantation
 - ◆ Left ventricular assist device (LVAD) is being used as destination therapy

CRID-4.3: Limited Life Expectancy

- ICD implantation is **not** indicated for individuals who do not have a reasonable expectation of survival with an acceptable functional status for at least one year, even if they meet ICD implantation criteria listed in:
 - ◆ **CRID-2: Definite Indications for ICD Implantation** or
 - ◆ **CRID-3: Reasonable Indications for ICD Implantation**

CRID-4.4: Incessant VT or VF

- ICD implantation is **not** indicated for individuals with incessant VT or VF
 - ◆ Incessant VT or VF is defined as hemodynamically stable VT or VF continuing for hours

CRID-4.5: Psychiatric Conditions

- ICD implantation is **not** indicated in individuals with significant psychiatric illnesses that may be aggravated by device implantation or that may preclude systematic follow-up

CRID-4.6: Reversible Cause of VT/VF

- ICD implantation is **not** indicated when VF or VT is due to a reversible cause such as:
 - ◆ Severe electrolyte disturbance
 - ◆ Drug-induced torsades de pointes
 - ◆ Acute, reperfused myocardial infarction with preserved ejection fraction

CRID-4.7: Ablation Candidate, No Structural Heart Disease

- ICD implantation is **not** indicated if the individual has no structural heart disease and is a candidate for ablation. Surgical or catheter ablation can be curative in this setting.

CRID-4.8: Substernal implantable cardioverter-defibrillator

- Substernal implantable cardioverter-defibrillator systems involve inserting a defibrillator lead directly beneath the sternum anterior to the heart, and is intended provide anti-tachycardia pacing as well as post-shock pacing without intravenous leads.
- At this time substernal implantable cardioverter-defibrillator systems are considered experimental and investigational.

CRID-5: Indications for Cardiac Resynchronization Therapy (CRT)-D Implantation

CRID-5.1: Sinus Rhythm, Dilated Cardiomyopathy with NYHA Class II, III, or IV Congestive Heart Failure (CHF)	23
CRID-5.2: Sinus Rhythm, Dilated Cardiomyopathy with NYHA Class II, III, or IV Congestive Heart Failure (CHF) and QRS duration 120-149 ms	23
CRID-5.3: Sinus Rhythm, Dilated Cardiomyopathy with non-LBBB and NYHA Class III or IV Congestive Heart Failure (CHF)	23
CRID-5.4: Atrial Fibrillation and NYHA Class I, II, or III Congestive Heart Failure	24
CRID-5.5: Cardiac Resynchronization Therapy (CRT)-P	24

CRID-5.1: Sinus Rhythm, Dilated Cardiomyopathy with NYHA Class II, III, or IV Congestive Heart Failure (CHF)

- CRT-D implantation is indicated in individuals with ischemic or nonischemic dilated cardiomyopathy who have **all** of the following:
 - ◆ Left bundle branch block with QRS greater than or equal to 150 msec
 - ◆ LV ejection fraction less than or equal to 35%
 - ◆ Are NYHA functional Class II, III, or ambulatory class IV on stable optimal medical therapy
 - Optimal medical therapy is defined as 3 months of maximally titrated doses as tolerated of an ACE inhibitor/angiotensin II receptor blocker, beta-blocker, and diuretic

CRID-5.2: Sinus Rhythm, Dilated Cardiomyopathy with NYHA Class II, III, or IV Congestive Heart Failure (CHF) and QRS duration 120-149 ms

- CRT-D implantation is indicated in individuals with ischemic or nonischemic dilated cardiomyopathy who have **all** of the following:
 - ◆ Left bundle branch block with QRS duration 120 to 149 msec
 - ◆ LV ejection fraction less than or equal to 35%
 - ◆ NYHA functional Class II, III, or ambulatory class IV on stable optimal medical therapy
 - Optimal medical therapy is defined as 3 months of maximally titrated doses as tolerated of an ACE inhibitor/angiotensin II receptor blocker, beta-blocker, and diuretic

CRID-5.3: Sinus Rhythm, Dilated Cardiomyopathy with non-LBBB and NYHA Class III or IV Congestive Heart Failure (CHF)

- CRT-D Implantation is indicated in individuals who have **all** of the following:
 - ◆ NYHA Class III, or IV Congestive Heart Failure
 - ◆ Non-LBBB with QRS duration greater or equal to 150 ms
 - ◆ LV ejection fraction less than or equal to 35%

CRID-5.4: Atrial Fibrillation and NYHA Class I, II, or III Congestive Heart Failure

- CRT is indicated in patients with AF and the following:
 - ◆ A left ventricular ejection fraction (LVEF) \leq 35 percent on guideline-directed medical therapy and all of the following:
 - The patient requires ventricular pacing or otherwise meets CRT criteria
“Meets CRT criteria” means either:
 - Has left bundle branch block (LBBB) and a QRS duration \geq 120 ms and New York Heart Association (NYHA) functional class II, III, or ambulatory class IV HF symptoms on stable optimal medical therapy;
 - or
 - Has a non-LBBB pattern with a QRS duration \geq 150 and NYHA class III or ambulatory class IV HF symptoms
 - Atrioventricular nodal ablation or pharmacologic rate control will allow near 100 percent ventricular pacing with CRT

CRID-5.5: Cardiac Resynchronization Therapy (CRT)-P

- See: **CRID-10: Cardiac Resynchronization Therapy (CRT)-P**

CRID-6: Cardiac Resynchronization Therapy (CRT)-D Implantation—Non-Indications

CRID-6.1: Ischemic Cardiomyopathy	26
CRID-6.2: Reversible Causes of Cardiomyopathy	26

CRID-6.1: Ischemic Cardiomyopathy

- CRT-D or CRT-P implantation is **not** indicated in individuals who have had a myocardial infarction within the past 40 days or who have had coronary revascularization within the past 90 days **unless** the following applies:
 - ◆ A separate indication for permanent pacemaker implantation exists (thus preventing a likely repeat procedure for an upgraded device in the near future)

CRID-6.2: Reversible Causes of Cardiomyopathy

- CRT-D implantation is not indicated in the setting of a reversible cardiomyopathy such as: toxic, metabolic, or tachycardia induced cardiomyopathy
 - ◆ Once the reversible aberration is corrected, clinical reassessment is indicated

CRID-7: Definite Indications for Permanent Pacemaker Implantation

CRID-7.1: Symptomatic Bradycardia	28
CRID-7.2: Symptomatic Chronotropic Incompetence	28
CRID-7.3: Indications for Asymptomatic Patients	28
CRID-7.4: Prior to Planned Catheter Ablation	28
CRID-7.5: Persistent Second Degree AV Block	29
CRID-7.6: Syncope	29

CRID-7.1: Symptomatic Bradycardia

- Permanent pacemaker implantation is indicated for symptomatic bradycardia, including frequent sinus pauses that produce symptoms and any degree of AV block producing symptoms
- Permanent pacemaker implantation is indicated for third-degree and advanced second-degree AV block at any anatomic level associated with ventricular arrhythmias presumed due to AV block, or any other medical conditions requiring drug therapy that results in symptomatic bradycardia (for example, beta blocker therapy in patients with prior myocardial infarction, or tachy-brady syndrome in atrial fibrillation).

CRID-7.2: Symptomatic Chronotropic Incompetence

- Permanent pacemaker implantation is indicated for symptomatic chronotropic incompetence defined as limitations due to the inability to achieve 80% of maximum predicted heart rate (220-age)

CRID-7.3: Indications for Asymptomatic Patients

- Permanent pacemaker implantation is indicated for asymptomatic patients with third degree AV block
- Permanent pacemaker implantation is indicated for asymptomatic patients with advanced second degree AV block (Mobitz type II) and intermittent third degree AV block
- Permanent pacemaker implantation is indicated for asymptomatic patients with second degree AV block and documented periods of asystole greater than or equal to 3.0 seconds
- Permanent pacemaker implantation is indicated for second degree AV block in awake, symptom-free patients with atrial fibrillation and a documented pause of 5 seconds or longer
- Permanent pacemaker implantation is indicated for alternating bundle branch block in asymptomatic patients.
- Permanent pacemaker implantation is indicated for asymptomatic patients with second degree AV block at any anatomic level associated with neuromuscular diseases known to involve the heart

CRID-7.4: Prior to Planned Catheter Ablation

- Permanent pacemaker implantation is indicated prior to a planned catheter ablation of the AV junction intended for a rate control strategy for management of atrial fibrillation

CRID-7.5: Persistent Second Degree AV Block

- Permanent pacemaker implantation is indicated for persistent second degree AV block in the His-Purkinje system with alternating bundle branch block or third degree AV block within or below the His-Purkinje system after myocardial infarction

CRID-7.6: Syncope

- Permanent pacemaker implantation is indicated for syncope caused by spontaneously occurring carotid sinus stimulation and carotid sinus pressure that induces ventricular asystole of more than 3 seconds

CRID-8: Reasonable Indications for Permanent Pacemaker Implantation

CRID-8.1: General Considerations	31
CRID-8.2: Sinus Node Dysfunction	31
CRID-8.3: Syncope	31
CRID-8.4: Asymptomatic Second Degree AV Block	31
CRID-8.5: First or Second AV Block	31
CRID-8.6: Symptomatic Recurrent SVT	31
CRID-8.7: Relative Bradycardia – Postoperative Cardiac Transplant	32
CRID-8.8: Incidental Finding at Electrophysiology (EP) Study	32
CRID-8.9: Neuromuscular Diseases Known to Involve the Heart	32
CRID-8.10: Cardiomyopathy with a history of heart failure and an LV Ejection Fraction less than 50% on optimal medical therapy	32

CRID-8.1: General Considerations

- For the “reasonable” or “considered” indications listed in this CRID-8 guideline, consensus opinion is less clear about permanent pacing in these settings, with evidence suggesting that device placement may be reasonable or may be considered

CRID-8.2: Sinus Node Dysfunction

- Permanent pacemaker implantation is reasonable for individuals with sinus node dysfunction with a resting heart rate of less than 40 bpm when periodic symptomatic bradycardia is suspected

CRID-8.3: Syncope

- Permanent pacemaker implantation may be reasonable or may be considered for individuals with syncope in the following settings:
 - ◆ Syncope of unexplained origin when clinically significant abnormalities of sinus node function are discovered or provoked in electrophysiological studies
 - ◆ Syncope without clear, provocative events and with a hypersensitive cardioinhibitory response of 3 seconds or longer
 - ◆ Significantly symptomatic neurocardiogenic syncope associated with Bradycardia documented spontaneously or at the time of tilt table testing
 - ◆ Syncope after cardiac transplantation even when bradyarrhythmia has not been documented

CRID-8.4: Asymptomatic Second Degree AV Block

- Permanent pacemaker implantation is reasonable for individuals with asymptomatic second degree AV block at intra- or infra- His levels found at electrophysiological study

CRID-8.5: First or Second AV Block

- Permanent pacemaker implantation is reasonable for individuals with first or second degree AV block with symptoms similar to those of pacemaker syndrome

CRID-8.6: Symptomatic Recurrent SVT

- Permanent pacemaker implantation is reasonable for individuals with symptomatic, recurrent SVT that is reproducibly terminated by pacing when catheter ablation and/or drugs fail to control the arrhythmia or produce intolerable side effects

CRID-8.7: Relative Bradycardia – Postoperative Cardiac Transplant

- Permanent pacemaker implantation may be considered for individuals when relative bradycardia is prolonged or recurrent, which limits rehabilitation or discharge after postoperative recovery from cardiac transplantation or in post-transplant syncope even if bradyarrhythmia has not been documented

CRID-8.8: Incidental Finding at Electrophysiology (EP) Study

- Permanent pacemaker implantation may be reasonable for an incidental finding at electrophysiology study of a markedly prolonged HV interval (greater than or equal to 100 milliseconds) or non-physiological intra- or infra- Hisian block in asymptomatic patients

CRID-8.9: Neuromuscular Diseases Known to Involve the Heart

- Permanent pacemaker implantation may be considered for progressive neuromuscular diseases known to involve the heart with any degree of AV block (including first degree AV block) or any fascicular block, with or without symptoms, because there may be unpredictable progression of AV conduction disease. Progressive neuromuscular diseases known to involve the heart include:
 - ◆ Myotonic muscular dystrophy
 - ◆ Kearns-Sayre syndrome
 - ◆ Erb dystrophy (limb-girdle muscular dystrophy)
 - ◆ Peroneal muscular atrophy

CRID-8.10: Cardiomyopathy with a history of heart failure and an LV Ejection Fraction less than 50% on optimal medical therapy

See: **CRID-10: Cardiac Resynchronization Therapy (CRT)-P**

CRID-9: Permanent Pacemaker Implantation

CRID-9.1: Non-Indications

34

CRID-9.1: Non-Indications

- Permanent pacemaker implantation is **not** indicated in any of the following settings:
 - ◆ Sinus node dysfunction in asymptomatic patients
 - ◆ Sinus node dysfunction in patients for whom the symptoms, suggestive of bradycardia, have been clearly documented to occur in the absence of bradycardia
 - ◆ Sinus node dysfunction in symptomatic patients due to nonessential drug therapy
 - ◆ Fascicular block without AV block or symptoms concerning for AV block
 - ◆ Incidentally noted hypersensitive cardioinhibitory response to carotid sinus stimulation without symptoms or with vague symptoms
 - ◆ Asymptomatic first degree AV block
 - ◆ Asymptomatic type I second degree AV block at the supra-His (AV node) level or that which is not known to be intra- or infra-Hisian
 - ◆ Permanent ventricular pacing not indicated for asymptomatic transient AV block in the absence of intraventricular conduction defects or in isolated single fascicular block
 - ◆ Permanent pacing not indicated for situational vasovagal syncope in which avoidance behavior is effective

CRID-10: Cardiac Resynchronization Therapy (CRT)-P

CRID-10.1: Indications for CRT-P

36

CRID-10.1: Indications for CRT-P

- High grade AV block and NYHA Class I, II or III Congestive Heart Failure:
 - ◆ CRT-P implantation is indicated in individuals who have **all** of the following:
 - LV ejection fraction less than 50%
 - NYHA Class I, II, or III heart failure
 - High grade AV block, including AV nodal ablation, requiring more than 40% pacing (CRT)-P

CRID-11: Leadless Implantable Devices

CRID-11.1: Leadless Pacemaker	38
CRID-11.2: Wireless Cardiac Resynchronization	38
CRID-11.3: Wireless Pulmonary Artery Pressure Sensor	38

CRID-11.1: Leadless Pacemaker

CRID-11.1.1: Leadless Pacemaker-general information

- Permanent RV leadless pacemakers (CPT® 33274) are implanted directly into the right ventricle and are capable only of VVI and VVIR pacing. They cannot be used for dual-chamber pacing, and the estimated battery life is about 10 years.

CRID-11.1.2: Leadless Pacemaker-Indications

- Indications for leadless pacer implant (BOTH):
 - ◆ Meets pacing indications per **CRID-7: Definite Indications for Permanent Pacemaker Implantation** or **CRID-8: Reasonable Indications for Permanent Pacemaker Implantation**
 - ◆ **None** of the following apply:
 - Patients with pacemaker syndrome or need for dual chamber pacing
 - Current implantation of neurostimulator or any other chronically implanted device which uses electrical current (includes ICDs)
 - Mechanical tricuspid valve, implanted vena cava filter, or left ventricular assist device
 - Elevated pulmonary pressures due to theoretical risk of embolization

CRID-11.2: Wireless Cardiac Resynchronization

- Permanent LV leadless pacemakers (CPT® 0515T) are implanted directly in the left ventricle for synchronization with RV leads in the setting of cardiac resynchronization therapy. At this time they are considered experimental and investigational.

CRID-11.3: Wireless Pulmonary Artery Pressure Sensor

- (CPT® 33289) Wireless Pulmonary Artery Pressure Sensor devices (CardioMEMS™ HF System) are implanted into a branch of the pulmonary artery during right heart catheterization and require a specialized delivery system. These devices monitor constant pulmonary artery pressures over time, utilizing the concept that as pulmonary artery pressures increase, outpatient medical therapy can be adjusted. This can potentially reduce inpatient admissions and treatment. Although FDA approved, these devices have yet to be incorporated into the standard of care and remain investigational and experimental at this time.

References

1. Josephson ME and Nisam S. The AVID trial executive committee. Are implantable cardioverter-defibrillators or drugs more effective in prolonging life? *Am J Cardiol.* 1997 Mar;79(5):661-663. DOI: doi:10.1016/S0002-9149(96)00834-X.
2. Kuck K-H, Cappato R, Siebels J, et al. Randomized Comparison of Antiarrhythmic Drug Therapy With Implantable Defibrillators in Patients Resuscitated From Cardiac Arrest. *Circulation.* 2000;102(7):748-754. doi:10.1161/01.cir.102.7.748.
3. Connolly SJ, Gent M, Roberts RS, et al. Canadian Implantable Defibrillator Study (CIDS). A randomized trial of the implantable cardioverter defibrillator against amiodarone. *Circulation.* 2000 Mar;101(11):1297-1302. doi:10.1161/01.cir.101.11.1297.
4. Gronefeld G, Connolly SJ, and Hohnloser SH. The Defibrillator in Acute Myocardial Infarction Trial (DINAMIT) rationale, design and specific aims. *Card Electrophysiol Rev.* 2003 Dec;7(4):447-451. doi:10.1023/B:CEPR.0000023154.52786.f4.
5. Steinbeck G, Andresen D, Seidl K, et al. Defibrillator implantation early after myocardial infarction.(IRIS). *N Engl J Med.* 2009 Oct;361:1427-1436. doi:10.1056/NEJMoa0901889.
6. Moss A, Hall W, Cannom D, et al. Cardiac-resynchronization therapy for the prevention of heart-failure events (MADIT2). *N Engl J Med.* 2009 Oct; 361:1329-1338. doi:10.1056/NEJMoa0906431.
7. Bardy G, Lee K, Mark D, et al. Amiodarone or an implantable cardioverter-defibrillator for congestive heart failure.(SCD-HeFT).*N Engl J Med.* 2005 Jan;352:225-37. doi:10.1056/NEJMoa043399.
8. Buxton AE, Lee KL, DiCarlo L, et al. Electrophysiologic testing to identify patients with coronary artery disease who are at risk for sudden death. Multicenter Unsustained Tachycardia Trial Investigators. (MUSTT). *N Engl J Med.*2000 Jun;342:1937-1945. doi:10.1056/NEJM200006293422602.
9. Epstein A, Dimarco J, Ellenbogen K, et al. ACC/AHA/HRS 2008 Guidelines for device-based therapy of cardiac rhythm abnormalities: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to revise the ACC/AHA/NASPE 2002 Guideline update for implantation of cardiac pacemakers and anti-arrhythmia devices): Developed in Collaboration With the American Association for Thoracic Surgery and Society of Thoracic Surgeons. *Circulation.* 2008 May;117(21). doi:10.1161/CIRCULATIONAHA.108.189742.
10. Russo AM, Stainback RF, Bailey SR, et al. ACCF/HRS/AHA/ASE/HFSA/SCAI/SCCT/SCMR 2013 appropriate use criteria for implantable cardioverter-defibrillators and cardiac resynchronization therapy: a report of the American College of Cardiology Foundation appropriate use criteria task force, Heart Rhythm Society, American Heart Association, American Society of Echocardiography, Heart Failure Society of America, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, and Society for Cardiovascular Magnetic Resonance. *J Am Coll Cardiol.* 2013 Apr; 10(4):e11-e58. doi:10.1016/j.jacc.2012.12.017.
11. Gersh BJ, Maron BJ, Bonow RO, et al. 2011 ACCF/AHA Guideline for the Diagnosis and Treatment of Hypertrophic Cardiomyopathy. *Circulation.* 2011;124(24). doi:10.1161/cir.0b013e318223e2bd.
12. Caliskan K, Szili-Torok T, Theuns D, et al. Indications and outcome of implantable cardioverter-defibrillators for primary and secondary prophylaxis in patients with noncompaction cardiomyopathy. *J Cardiovasc Electrophysiol.* 2011 Aug;22(8):898–904. doi:10.1111/j.1540-8167.2011.02015.x.
13. Zareba W, Klein H, Cygankiewicz I, et al. Effectiveness of cardiac resynchronization therapy by QRS morphology in Multicenter Automatic Defibrillator Implantation Trial – Cardiac Resynchronization Therapy (MADIT-CRT). *Circulation.* 2011 Mar;123(10):1061-1072. doi:10.1161/CIRCULATIONAHA.110.960898.
14. Tang AS, Wells GA, Talajic M, et al. Cardiac-Resynchronization Therapy for Mild-to-Moderate Heart Failure. *New England Journal of Medicine.* 2010;363(25):2385-2395. doi:10.1056/nejmoa1009540.
15. Linde C, Gold MR, Abraham WT, et al. Rationale and design of a randomized controlled trial to assess the safety and efficacy of cardiac resynchronization therapy in patients with asymptomatic left ventricular dysfunction with previous symptoms or mild heart failure—the Resynchronization reVERses Remodeling in Systolic left ventricular dysfunction (REVERSE) study. *Am Heart J.* 2006 Feb;151(2):288-294. doi:10.1016/j.ahj.2005.03.002.
16. Tracy C, Epstein A, Darbar D, et al. 2012 ACCF/AHA/HRS focused update of the 2008 guidelines for device-based therapy of cardiac rhythm abnormalities: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *J Thorac Cardiovasc Surg.* 2012 Dec; 144(6): e127–e145. doi:10.1016/j.jtcvs.2012.08.032.

17. Yancy CW, Jessup M, Bozkurt B, et al. 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines. *Circulation*. 2013 Oct;128:e240-e327. doi:10.1161/CIR.0b013e31829e8776.
18. Daubert J-C, Saxon L, Adamson PB, et al. 2012 EHRA/HRS expert consensus statement on cardiac resynchronization therapy in heart failure: implant and follow-up recommendations and management: A registered branch of the European Society of Cardiology (ESC), and the Heart Rhythm Society; and in collaboration with the Heart Failure Society of America (HFSA), the American Society of Echocardiography (ASE), the American Heart Association (AHA), the European Association of Echocardiography (EAE) of the ESC and the Heart Failure Association of the ESC (HFA). * Endorsed by the governing bodies of AHA, ASE, EAE, HFSA, HFA, EHRA, and HRS. *Europace*. 2012;14(9):1236-1286. doi:10.1093/europace/eus222.
19. Healey JS, Hohnloser SH, Exner DV, et al. Cardiac resynchronization therapy in patients with permanent atrial fibrillation: results from the Resynchronization for Ambulatory Heart Failure Trial (RAFT). *Circulation:Heart failure*. 2012 Sept;5(5):566-570. doi:10.1161/CIRCHEARTFAILURE.112.968867.
20. Curtis AB, Worley SJ, Adamson PB, et al. Biventricular pacing for atrioventricular block and systolic dysfunction. *N Engl J Med*. 2013 Apr; 368:1585-93. Accessed October 25, 2017. doi:10.1056/NEJMoa1210356.
21. Bristow MR, Saxon LA, Boehmer J, et al. Cardiac-Resynchronization Therapy with or without an Implantable Defibrillator in Advanced Chronic Heart Failure. *N Engl J Med*. 2004 May; 350:2140-2150. doi:10.1056/NEJMoa032423.
22. Kay R, Estioko M, and Wiener I. Primary sick sinus syndrome as an indication for chronic pacemaker therapy in young adults: incidence, clinical features, and long-term evaluation. *Am Heart J*. 1982 Mar;103(3):338-42. doi:10.1016/0002-8703(82)90271-x.
23. Kusumoto F and Goldschlager N. Cardiac pacing. *N Engl J Med*. 1996 Jan; 334:89-99. doi:10.1056/NEJM199601113340206.
24. Rasmussen K. Chronic sinus node disease: natural course and indications for pacing. *Euro Heart J*. 1981 Dec;2(6):455-459. doi:10.1093/oxfordjournals.eurheartj.a061236.
25. Linde-Edelstam C, Nordlander R, Pehrsson SK, et al. A double-blind study of submaximal exercise tolerance and variation in paced rate in atrial synchronous compared to activity sensor modulated ventricular pacing. *PACE*. 1992 Jun;15(6):905-15. doi:10.1111/j.1540-8159.1992.tb03081.x.
26. Charles R, Holt S, Kay JM, et al. Myocardial ultrastructure and the development of atrioventricular block in Kearns-Sayre syndrome. *Circulation*. 1981 Jan;63(1):214-219. doi:10.1161/01.cir.63.1.214.
27. Clemmensen P, Bates ER, Califf RM, et al. Complete atrioventricular block complicating inferior wall acute myocardial infarction treated with reperfusion therapy. TAMI Study Group. *Am J Cardiol*. 1991 Feb;67(4):225-230. doi:10.1016/0002-9149(91)90550-5.
28. Ector H, Rolies L, and De Geest H. Dynamic electrocardiography and ventricular pauses of 3 seconds and more: etiology and therapeutic implications. *PACE*. 1983 May;6(3):548-551. doi:10.1111/j.1540-8159.1983.tb05294.x.
29. Glikson M, Dearani JA, HybergerLK, et al. Indications, effectiveness, and long-term dependency in permanent pacing after cardiac surgery. *Am J Cardiology*. 1997 Nov;80(10):1309-13. doi:10.1016/S0002-9149(97)00671-1.
30. Hiromasa S, Ikeda T, Kubota K, et al. Myotonic dystrophy: ambulatory electrocardiogram, electrophysiologic study, and echocardiographic evaluation. *Am Heart J*. 1987 Jun;113(6):1482-1488. Doi:10.1016/0002-8703(87)90665-X.
31. Kastor JA. Atrioventricular block (first of two parts). *N Engl J Med*. 1975;292:462-5. doi:10.1056/NEJM197502272920906.
32. Kastor JA. Atrioventricular block (second of two parts). *N Engl J Med*. 1975 Mar;292:572-574. doi:10.1056/NEJM197503132921106.
33. Perloff JK, Stevenson WG, Roberts NK, et al. Cardiac involvement in myotonic muscular dystrophy (Steinert's disease): a prospective study of 25 patients. *Am J Cardiol*. 1984 Nov;54(8):1074-81. Doi:10.1016/S0002-9149(84)80147-2.
34. Zipes DP. Second-degree atrioventricular block. *Circulation*. 1979 Sept;60(3):465-72. Doi:10.1161/01.CIR.60.3.465.

35. LangbergJJ, Chin MC, Rosenqvist M, et al. Catheter ablation of the atrioventricular junction with radiofrequency energy. *Circulation*. 1989Dec;80(6):1527-1535. Doi:10.1161/01.CIR.80.6.1527.
36. Fujimura O, Klein GJ, Yee R, et al. Mode of onset of atrial fibrillation in the Wolff-Parkinson-White syndrome: How important is the accessory pathway? *J Am Coll Cardiol*. 1990 Apr;15(5):1082-1086. doi:10.1016/0735-1097(90)90244-J.
37. Reiffel J and Kuehnert M. Electrophysiological testing of sinus node function: diagnostic and prognostic application-including updated information from sinus node electrograms. *PACE*. 1994 Mar;17(3):349-65. Doi:10.1111/j.1540-8159.1994.tb01397.x.
38. Sheldon R, Koshman ML, Wilson W, et al. Effect of dual-chamber pacing with automatic rate-drop sensing on recurrent neurally mediated syncope. *Am J Cardiol*. 1998 Jan;81(2):158-162. doi:10.1111/j.1540-8159.1994.tb01397.x.
39. Barold SS. Indications for permanent cardiac pacing in first-degree AV block: class I, II, or III? *PACE*. 1996 May;19(5):747-751. doi:10.1111/j.1540-8159.1996.tb03355.x.
40. Connelly DT and Steinhaus DM. Mobitz type I atrioventricular block: an indication for permanent pacing? *PACE*. 1996 Mar;19(3):261-264. doi:10.1111/j.1540-8159.1996.tb03325.x.
41. British Pacing and Electrophysiology Group. Recommendations for pacemaker prescription for symptomatic bradycardia. Report of a working party of the British Pacing and Electrophysiology Group. *Br Heart J*. 1991;66(2):185–191.
42. Connolly SJ, Sheldon R, Thorpe KE, et al. Pacemaker therapy for prevention of syncope in patients with recurrent severe vasovagal syncope: Second Vasovagal Pacemaker Study (VPS II): a randomized trial. *JAMA*. 2003;289(17):2224-2229. doi:10.1001/jama.289.17.2224.
43. Epstein AE, DiMarco JP, Ellenbogen KA, et al. 2012 ACCF/AHA/HRS Focused Update of the 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities: A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2012 Sept;126(14):p1784-1800. doi:10.1161/CIR.0b013e3182618569.
44. Al-Khatib SM, Stevenson WG, Ackerman MJ, et al. 2017 AHA/ACC/HRS Guideline for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death. *Circulation*. 2018;138(13). doi:10.1161/cir.0000000000000549.
45. Kusumoto FM, Calkins H, Boehmer J, et al. HRS/ACC/AHA expert consensus statement on the use of implantable cardioverter-defibrillator therapy in patients who are not included or not well represented in clinical trials. *J Am Coll Cardiol* 2014;64:1143–77. doi:10.1161/CIR.0000000000000056.
46. Pacing Without Wires: Leadless Cardiac Pacing. Ochsner J. 2016;16(3):238-42. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5024804/pdf/i1524-5012-16-3-238.pdf>.
47. Abraham WT, Perl L. Implantable Hemodynamic Monitoring for Heart Failure Patients. *Journal of the American College of Cardiology*. 2017;70(3):389-398. doi:10.1016/j.jacc.2017.05.052.
48. Reddy VY, Miller MA, Neuzil P, et al. Cardiac Resynchronization Therapy With Wireless Left Ventricular Endocardial Pacing. *Journal of the American College of Cardiology*. 2017;69(17):2119-2129. doi:10.1016/j.jacc.2017.02.059.
49. Kirkfeldt RE, Johansen JB, Nohr EA, et al. Complications after cardiac implantable electronic device implantations: an analysis of a complete, nationwide cohort in Denmark. *Eur Heart J*. 2014;35:1186–1194. doi:10.1093/eurheartj/eh511.
50. Udo EO, Zuithoff NPA, van Hemel NM, et al. Incidence and predictors of short and long-term complications in pacemaker therapy: The FOLLOWPACE study. *Heart Rhythm*. 2012;9:728–735. doi:10.1016/j.hrthm.2011.12.014.
51. Reynolds D, Duray GZ, Omar R, et al. A leadless intracardiac transcatheter pacing system. *N Engl J Med*. 2016;374:533–541. doi:10.1056/NEJMoa1511643.
52. Tracy CM, Epstein AE, Darbar D, et al. 2012 ACCF/AHA/HRS Focused Update Incorporated into the ACCF/AHA/HRS 2008 Guidelines for Device-Based Therapy of Cardiac Rhythm Abnormalities: A Report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. *J Am Coll Cardiol*. 2013;61:e6–e75. doi:10.1016/j.jacc.2012.11.007.
53. Okabe T, El-Chami MF, Lloyd MS, et al. Leadless pacemaker implantation and concurrent atrioventricular junction ablation in patients with atrial fibrillation. *Pacing Clin Electrophysiol*. doi:10.1111/pace.13312. Published Online First: Feb 24, 2018

54. Epstein AE, DiMarco JP, Ellenbogen KA, et al. ACC/AHA/HRS 2008 guidelines for device based therapy of cardiac rhythm abnormalities: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the ACC/AHA/NASPE 2002 Guideline Update for Implantation of Cardiac Pacemakers and Antiarrhythmia Devices). *Circulation*. 2008; 117:e350–e408. doi: 10.1161/CIRCULATIONAHA.108.189742.
55. Boersma LV, Merkely B, Neuzil P, et al. Therapy From a Novel Substernal Lead. *JACC: Clinical Electrophysiology*. 2019;5(2):186-196. doi:10.1016/j.jacep.2018.11.003.