Ventricular Arrhythmia

Clinical Guidelines for Medical Necessity Review

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Important Notices

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Other Notices:

Guideline Information:

Disease Area: Cardiology
Care Path Group: Arrhythmias
Care Path Name: Ventricular Arrhythmia
Type: [**X**] Adult (18+ yo) | [_] Pediatric (0-17yo)

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Care Path Overview

Care Path Clinical Discussion

Ventricular arrhythmias include a range of conditions, including isolated ventricular ectopy to ventricular fibrillation, and can be asymptomatic, incidental findings, or present with sudden cardiac arrest.

Premature ventricular contractions (PVCs) increase in frequency with age. About 50% of adults will have PVCs present on routine ambulatory cardiac monitoring.[1] Studies have demonstrated that high-frequency PVC burden increases the probability of left ventricular remodeling, diminished function, and increased incidence of cardiac events.[2,3] Higher frequency of cardiac events is also linked to polymorphic PVCs, which imply a more diffuse or disorganized electrical substrate. In these patients, it is particularly important to investigate forms of structural heart disease that can produce more aggressive ventricular arrhythmias.[1,4] These can include but are not limited to:

- Myocardial scarring or development of ischemic cardiomyopathy from CAD.
- Nonischemic cardiomyopathy.
- Cardiac sarcoidosis.
- Cardiac amyloidosis.
- Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC).
- Hypertrophic Cardiomyopathy (HCM).

Each of these conditions has unique features which require different imaging tools to help make the diagnosis. They can also present with more sustained ventricular tachycardia or ventricular fibrillation arrest.

More sustained ventricular arrhythmias are often seen in the setting of ischemic heart disease. Over 50% of patients presenting with ventricular fibrillation have evidence of acute myocardial infarction.[1] About 7.6% of patients with non-ST segment elevation myocardial infarction have VT or even VF within 48 hours of presentation. Sustained ventricular tachycardia (VT) or ventricular fibrillation (VF) after 48 hours from primary PCI is associated wh higher 90-day mortality than those with no ventricular arrhythmias or VT/VF less than 48 hours after treatment.[1,5]

Monomorphic VT is often found in patients with a history of myocardial infarction caused by residual scar creating a stable electrical circuit. This is often amenable to cardiac ablation. These scar-mediated ventricular tachycardias are also found in ischemic and nonischemic cardiomyopathy and can degenerate into ventricular fibrillation.[6]

Monomorphic VT in a structurally normal heart is often called idiopathic VT, often found in younger patients. These rhythms can still be quite symptomatic and may be treatable with antiarrhythmics or catheter ablation.

Polymorphic VT or VF in normal or structurally abnormal hearts have a more ominous prognosis. In a normal heart, findings of polymorphic VT, Torsades de Pointes, or VF imply a genetic cardiac channelopathy or a medication-induced long QT syndrome. However, not uncommonly, the diagnosis is elusive. Polymorphic VT/VF in structural heart disease is most commonly associated with ischemic heart disease, but other forms of cardiomyopathy, cardiac infiltrative disease, or channelopathy can cause these rhythm abnormalities.

The goal of any evaluation of sustained ventricular arrhythmias is to:

1. Mitigate their risk for progression.
2. Prevent sudden cardiac arrest.

The information contained herein gives a general overview of the pathway of this specific diagnosis, beginning with the initial presentation, recommended assessments, and treatment options as supported by the medical literature and existing guidelines. It should be noted that the care of patients can be complex. The information below is meant to support clinical decision-making in adult patients. It is not necessarily applicable to every case, as the entire clinical picture (including comorbidities, history, etc.) should be considered.

Key Information

- ➢ PVCs are often seen in patients with routine ambulatory cardiac monitoring. A high burden of ectopy can lead to ventricular remodeling and reduced function, and symptoms of heart failure (exercise intolerance, shortness of breath, neck or chest fullness).[2,3]
- ➢ Monomorphic VT is often seen after myocardial infarction. Medications and catheter ablation can be effective at treating this arrhythmia to prevent degeneration into VF. As scarring can be progressive, new VT circuits can arise and need additional procedures (i.e., ablation) for treatment.[1,6]
- ➢ Ischemic heart disease remains the most common underlying substrate associated with SCD, the incidence of ischemic heart disease-related SCD appears to be decreasing. Various forms of cardiomyopathy associated with myocardial fibrosis and LV hypertrophy have taken an increasing proportion of these events.[1,7]
- ➢ Polymorphic VT and VF are malignant arrhythmias regardless of etiology. Without a clear trigger that can be treated, these patients often need an ICD implanted for secondary prevention of sudden cardiac death.
- ➢ Aborted sudden cardiac arrest in a patient without evidence of ischemic heart disease should be evaluated for a genetic channelopathy. If genetic testing is positive, first-degree relatives should also be screened.[1,6]

Definitions

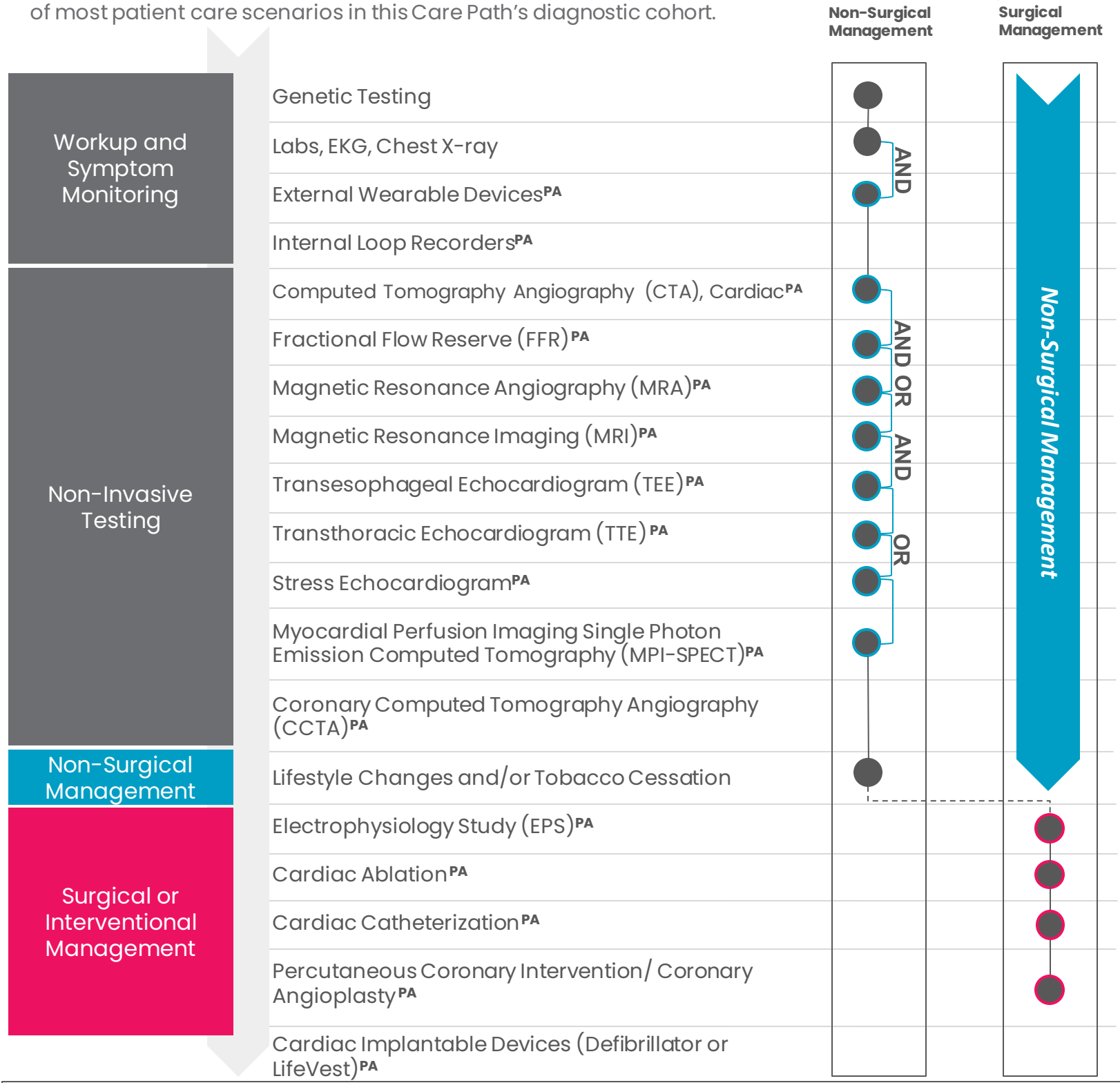
- **Pre-Test Probability:** The pretest probability of CAD is the likelihood that the patient has CAD, calculated before the test result is known. These guidelines reference the 2019 European Society of Cardiology (ESC) Guidelines for the diagnosis and management of chronic coronary syndromes model to calculate the pretest probability based on age, sex, and type of chest pain.[8,9]
- **Ventricular tachycardia (VT):** cardiac arrhythmia of ≥3 consecutive complexes originating in the ventricles at a rate greater than 100 BPM. Sustained VT describes a sequence of beats that last for at least 30 seconds.
- **Monomorphic:** Having the same waveform shape from beat to beat.
- **Polymorphic:** Having variable waveform shape from beat to beat.
- **Ventricular Fibrillation (VF):** Rapid, disorganized, and irregular ventricular rhythm, which often has a rate of over 300 BPM. This is a clinically unstable rhythm requiring electrical defibrillation to convert.

- **Ventricular Flutter:** a regular ventricular arrhythmia with about 300 BPM with a sinusoidal, monomorphic appearance; no isoelectric interval between successive QRS complexes. This is a clinically unstable rhythm requiring electrical defibrillation to convert.
- **Torsades de Pointes:** a polymorphic VT that occurs due to a long QT interval and is characterized by alternating larger and smaller QRS amplitudes.
- **Sudden Cardiac Arrest (SCA):** An event resulting in rapid loss of perfusion to critical organs, usually caused by unstable VT or VF. Out of the hospital, SCA has very poor survival rates, still about 10%.
- **Clinical Classification of Chest Pain**[10,61]:
    - **Cardiac Pain (Typical Angina, Definite):** Substernal chest pain or discomfort that is provoked by exertion or emotional stress and relieved by rest or nitroglycerin.
    - **Possible Cardiac Pain (Atypical Angina, Probable):** Chest pain or discomfort that lacks 1 of the characteristics of definite or typical angina.
    - **Noncardiac Pain (Nonanginal Chest Pain):** Chest pain or discomfort that meets 0 or 1 of the typical angina characteristics.
- **Symptomatic/Ischemic Equivalent**[61]: Chest pain syndrome, anginal equivalent, or ischemic electrocardiogram (ECG) abnormalities are clinical findings that the physician believes are consistent with CAD manifestations. Examples include pain, pressure, tightness, or discomfort in the chest, shoulders, arms, neck, back, upper abdomen, or jaw, new ECG abnormalities, or other symptoms/findings suggestive of CAD. Clinical presentations in the absence of chest pain (e.g., dyspnea with exertion, fatigue, or reduced/worsening effort tolerance) consistent with CAD may also be considered an ischemic equivalent.
- **Canadian Cardiovascular Society grading of Angina Pectoris**:
    - Grade I: Ordinary physical activity does not cause angina, such as walking and climbing stairs. Angina with strenuous or rapid or prolonged exertion at work or recreation.
    - Grade II: Slight limitation of ordinary activity. Walking or climbing stairs rapidly, walking uphill, walking or stair climbing after meals, in the cold, in the wind, under emotional stress, or only during the few hours after awakening. Walking more than two blocks on the level and climbing more than one flight of ordinary stairs at a normal pace and in normal conditions.
    - Grade III: Marked limitation of ordinary physical activity. Walking one or two blocks on the level and climbing one flight of stairs in normal conditions and at a normal pace.
    - Grade IV: Inability to carry on any physical activity without discomfort; anginal syndrome may be present at rest.

Ventricular Arrhythmias

What is a "Cohere Care Path"?

These Care Paths organize the services typically considered most clinically optimal and likely to be automatically approved. These service recommendations also include the suggested sequencing and quantity or frequency determined clinically appropriate and medically necessary for the management of most patient care scenarios in this Care Path's diagnostic cohort.



Key

PA = Service may require prior authorization
★ = Denotes preferred service
AND = Services completed concurrently
OR = Services generally mutually exclusive

= Rate Control management prior authorization group of services
= Rhythm Control management prior authorization group of services
= Subsequent service
= Management path moves to a different management path

Care Path Diagnostic Criteria

Disease Classification

Arrhythmias, Ventricular

ICD-10 Codes Associated with Classification

ICD-10 Code	Code Description/Definition
I45.81	Long QT syndrome
I46.2	Cardiac arrest due to underlying cardiac condition
I46.8	Cardiac arrest due to other underlying condition
I47.0	Re-entry ventricular arrhythmia
I47.2	Ventricular tachycardia
I47.20	Ventricular tachycardia, unspecified
I47.21	Torsades de pointes
I47.29	Other ventricular tachycardia
I49.0	Ventricular fibrillation and flutter
I49.01	Ventricular fibrillation
I49.02	Ventricular flutter
I49.3	Ventricular premature depolarization
I49.4	Other and unspecified premature depolarization
I97.120	Postprocedural cardiac arrest following cardiac surgery
I97.121	Postprocedural cardiac arrest following other surgery
I97.711	Intraoperative cardiac arrest during other surgery
I49.40	Unspecified premature depolarization
I49.49	Other premature depolarization
I49.8	Other specified cardiac arrhythmias
I49.9	Cardiac arrhythmia, unspecified
R00.0	Tachycardia, unspecified
R00.9	Unspecified abnormalities of heart beat

T82.110A	Breakdown (mechanical) of cardiac electrode, initial encounter
T82.110D	Breakdown (mechanical) of cardiac electrode, subsequent encounter
T82.111A	Breakdown (mechanical) of cardiac pulse generator (battery), initial encounter
T82.118D	Breakdown (mechanical) of other cardiac electronic device, subsequent encounter
T82.119A	Breakdown (mechanical) of unspecified cardiac electronic device, initial encounter
T82.120A	Displacement of cardiac electrode, initial encounter
T82.121A	Displacement of cardiac pulse generator (battery), initial encounter
T82.128A	Displacement of other cardiac electronic device, initial encounter
T82.190A	Other mechanical complication of cardiac electrode, initial encounter
T82.191A	Other mechanical complication of cardiac pulse generator (battery), initial encounter
T82.98A	Other mechanical complication of other cardiac electronic device, initial encounter
T82.198S	Other mechanical complication of other cardiac electronic device, sequela
T82.199A	Other mechanical complication of unspecified cardiac device, initial encounter
T82.518A	Breakdown (mechanical) of other cardiac and vascular devices and implants, initial encounter
T82.598A	Other mechanical complication of other cardiac and vascular devices and implants, initial encounter
T82.598D	Other mechanical complication of other cardiac and vascular devices and implants, subsequent encounter
T82.7XXA	Infection and inflammatory reaction due to other cardiac and vascular devices, implants and grafts, initial encounter

T82.7XXD	Infection and inflammatory reaction due to other cardiac and vascular devices, implants and grafts, subsequent encounter
T82.837A	Hemorrhage due to cardiac prosthetic devices, implants and grafts, initial encounter
T82.867D	Thrombosis due to cardiac prosthetic devices, implants and grafts, subsequent encounter
T82.897A	Other specified complication of cardiac prosthetic devices, implants and grafts, initial encounter
T82.897S	Other specified complication of cardiac prosthetic devices, implants and grafts, sequela
T85.698A	Other mechanical complication of other specified internal prosthetic devices, implants and grafts, initial encounter
Z45.010	Encounter for checking and testing of cardiac pacemaker pulse generator [battery]
Z45.018	Encounter for adjustment and management of other part of cardiac pacemaker
Z45.02	Encounter for adjustment and management of automatic implantable cardiac defibrillator
Z95.810	Presence of automatic (implantable) cardiac defibrillator

Presentation and Etiology

Causes and Risk Factors

Ventricular arrhythmias have a variety of causes. Some patients with monomorphic PVCs or VT do not have any identifiable etiology for their arrhythmia. However, other conditions, a few of which can be reversible, are causes of ventricular ectopy or more sustained arrhythmias:

- CAD.
- Myocardial infarction.
- Cardiomyopathies (dilated, hypertrophic, restrictive).
- Genetic channelopathies (Long QT Syndrome, catecholaminergic polymorphic VT, Short QT Syndrome, Brugada Syndrome).
- Idiopathic ventricular rhythms (e.g., Ventricular Outflow Tract Tachycardia, fascicular VT).

- Electrolyte abnormalities (e.g., hypokalemia, hypomagnesemia, acidosis).
- Intracardiac masses.
- Infection or inflammation.
- Drugs (antiarrhythmics Classes IA, IC, III).
- Infiltrative diseases (e.g., sarcoidosis).

Clinical Presentation

Ventricular arrhythmias can arise spontaneously and often are asymptomatic. It is very common for isolated PVCs to go undetected for a prolonged period before they are identified on auscultation. Nonsustained VT is also commonly seen in cardiac monitoring. Patients who feel these abnormal beats can feel a skipping or squeezing in their chest or state they have the urge to cough. Frequent ventricular ectopy over time can start to produce symptoms of heart failure when there is a large enough arrhythmia burden.

Ventricular tachycardia, which is frequent, rapid, or prolonged, can easily cause low blood pressure and reduce perfusion to the body. This can cause significant symptoms, the most common being syncopal events. Any syncope occurring with exertion, associated with sudden chest pain or palpitations, or in the setting of a history of ischemic heart disease should be considered high-risk for ventricular arrhythmia.[6] Other symptoms which may be observed include:

- Dizziness.
- Worsening heart failure.
- Fatigue and exercise intolerance.
- Cognitive changes/confusion.
- Cardiovascular collapse/shock.

Presentation with sustained ventricular fibrillation (VF) is an emergency situation; the patient is usually unconscious, and CPR and other lifesaving measures are being taken. However, in patients presenting with acute coronary events, a significant percentage of these patients may have nonsustained runs of VF before and after coronary interventions.

Typical Physical Exam Findings

The focus of the physical examination should be an evaluation of hemodynamic consequences due to frequent or sustained ventricular arrhythmias, including:

- Weak or dampened pulses.
- Sluggish capillary refill.

- Cognitive changes/confusion.

The cardiac exam should focus on evidence of the following:
- Evidence of ongoing rhythm disturbances on auscultation.
- Murmurs suggesting structural heart disease.
- Exaggerated or irregular jugular venous pulsation.
- Pulmonary crackles/decreased breath sounds suggesting left heart failure.
- Liver enlargement/congestion suggesting right heart failure.
- Peripheral edema.

Typical Diagnostic Findings

Initial diagnostic workup should begin with a 12-lead ECG. The frequency and type of ventricular ectopy or more sustained arrhythmia should be noted. The 12 lead ECG should also be examined for signs of other cardiac pathology, including ischemic changes.[1,6]

With suspicion of ventricular arrhythmias causing recurring and episodic symptoms, extended ambulatory electrocardiographic monitoring is recommended. Implantable loop recorders can be helpful for symptoms that infrequently occur, especially unexplained syncope, when external monitoring does not yield a definitive diagnosis.[6]

In certain clinical scenarios, after an exam and assessment of the presenting rhythm, initial interventions may include:
- Removing any medications which might contribute to the development of ventricular arrhythmias.
- Treatment of underlying systemic conditions.
- Use of antiarrhythmics to control frequent or symptomatic ventricular rhythms.
- Performing laboratory studies evaluating electrolytes, drug levels, blood gases, and pH to detect conditions that can acutely be corrected.

With a history of prior cardiac disease or cardiac surgery/intervention, evaluation with cardiac imaging is appropriate, such as any of the following:
- Transthoracic echocardiography can better assess cardiac function and define anatomic abnormalities, which underlie the ventricular arrhythmia.
- Cardiac MRI can define structural heart disease and myocardial fibrosis/infiltrative disease, which may inform future VT/VF risk and sudden cardiac arrest.
- Cardiac CT imaging can be useful for the assessment of cardiac anatomy and function. Coronary CTA can add value to an assessment

of coronary patency; however, it is less sensitive for evaluating diseases of the myocardium.
- Stress testing can be useful when symptoms potentially related to conduction disease are linked to exertion. When risk factors for CAD are present, additional imaging with echocardiography or radionuclide scanning is appropriate.
- Ventricular arrhythmias associated with other symptoms of myocardial infarction are best addressed by cardiac catheterization for an attempt at coronary reperfusion.[6]

Monomorphic ventricular tachycardias (each beat having the same waveform appearance) are often amenable to mapping and catheter ablation. This is a recommended intervention to reduce the arrhythmia burden and to prevent the degeneration of sustained VT to VF.

In cases of polymorphic VT, VF, or aborted SCA, which does not have a treatable cause (e.g., acute coronary syndrome, electrolyte abnormalities, drug effect), patients benefit from an implantable cardioverter-defibrillator (ICD) for prevention of sudden cardiac death. Pacing alone is not an effective treatment for ventricular arrhythmias. For certain patients who have had an implanted device infection or cardiac events or interventions where the cardiac function may initially be reduced but has the potential to recover, a wearable defibrillator may be appropriate for temporary protection.

Care Path Services & Medical Necessity Criteria

Workup and Symptom Monitoring

Service: Genetic Testing

General Guidelines

- **Units, Frequency, & Duration:** None.
- **Criteria for Subsequent Requests:** Testing for a specific genetic disease is indicated once unless new capabilities for detecting additional mutations develop.
- **Recommended Clinical Approach:** Genetic testing should be considered in several inherited arrhythmogenic diseases associated with an increased risk of ventricular arrhythmia and SCD. These conditions include:
    - Long QT Syndrome (LQTS).
    - Short QT Syndrome (SQTS).
    - Catecholaminergic Polymorphic VT (CPVT).
    - Brugada Syndrome (BrS).

  These conditions can present with unexplained syncope or an aborted cardiac arrest. They are often elicited on either baseline 12-lead ECG, ECG stress testing, longer duration cardiac monitoring, or occasionally, testing with epinephrine infusion.[11,12,13,14]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **Genetic testing** is considered appropriate if **ANY** of the following is **TRUE**:

- ◆
- ◆ Documented Torsades de Pointes-LQTS.
- ◆ Syncope or aborted SCA associated with a prolonged QTc interval on 12 lead ECG-LQTS.
- ◆ A corrected QT interval of less than 340 milliseconds-SQTS.[11]
- ◆ Bidirectional VT (The QRS axis or morphology is alternating in the frontal plane leads from beat to beat.) during stress testing -CPVT.

- ST-segment changes on 12 lead ECG or after drug challenge in Brugada Syndrome.[15]
- 1st-degree family member with any of these named disorders.

Non-Indications

➔ **Genetic testing** is not considered appropriate if **ANY** of the following is **TRUE**:

- If genetic testing has already been completed.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
81422	Genomic Sequencing Procedures and Other Molecular Multianalyte Assays
81439	Hereditary cardiomyopathy (eg, hypertrophic cardiomyopathy, dilated cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy), genomic sequence analysis panel, must include sequencing of at least 5 cardiomyopathy-related genes (eg, DSG2, MYBPC3, MYH7, PKP2, TTN)
81413	Cardiac ion channelopathies (eg, Brugada syndrome, long QT syndrome, short QT syndrome, catecholaminergic polymorphic ventricular tachycardia); genomic sequence analysis panel, must include sequencing of at least 10 genes, including ANK2, CASQ2, CAV3, KCNE1, KCNE2, KCNH2, KCNJ2, KCNQ1, RYR2, and SCN5A
81414	Cardiac ion channelopathies (eg, Brugada syndrome, long QT syndrome, short QT syndrome, catecholaminergic polymorphic ventricular tachycardia); duplication/deletion gene analysis panel, must include analysis of at least 2 genes, including KCNH2 and KCNQ1

Service: Genetic Testing, CYP2D6

General Guidelines

- **Units, Frequency, & Duration:** None.
- **Criteria for Subsequent Requests:** Complete testing for a specific genetic disease only once unless new capabilities for detecting additional mutations develop.
- **Recommended Clinical Approach:** Cytochrome P450 2D6 (CYP2D6) is a pre-dominant metabolizing enzyme for up to 20% of commonly used drugs, and its human gene displays substantial genetic variability. The genetic variation can cause vast differences in clinical responses to drugs between patients.[16] Cardiovascular drugs such as propafenone, metoprolol, and carvedilol are partially metabolized through this enzyme.[17] However, there is not yet a consensus on which *CYP2D6* variants should be routinely tested for clinical use.[18] The pace of genetic discovery has outstripped the generation of the evidence justifying its clinical adoption.[19]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **Genetic testing** [CYP2D6 genotyping (Cytochrome P450, family 2, subfamily D, polypeptide 6) (eg, drug metabolism), gene analysis, common variants] is considered appropriate if **ALL** of the following are **TRUE**:

- ◆ The use of the drug propafenone.[17,19]
- ◆ The patient has not had prior genetic testing for the gene.

Non-Indications

➔ **Genetic testing**[CYP2D6 genotyping (Cytochrome P450, family 2, subfamily D, polypeptide 6) (eg, drug metabolism), gene analysis, common variants]is not considered appropriate if **ANY** of the following is **TRUE**:

- ◆ Genetic testing for the CYP2D6 gene was already completed.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
81226	CYP2D6 (cytochrome P450, family 2, subfamily D, polypeptide 6) (eg, drug metabolism), gene analysis, common variants (eg, *2, *3, *4, *5, *6, *9, *10, *17, *19, *29, *35, *41, *1XN, *2XN, *4XN)

Service: Internal Loop Recorders

General Guidelines

- **Units, Frequency, & Duration:** When medical necessity criteria are met in the absence of exclusionary criteria, referral to a cardiac electrophysiologist for the implant of an internal loop recorder (ILR) can be indicated. A single outpatient procedure is anticipated. The duration of the implant can be up to 4 years, depending on the device's battery life. Periodic recordings are actively or passively transmitted for interpretation by a physician.[20,21]
- **Criteria for Subsequent Requests:** Subsequent requests are only accepted with documentation of device malfunction, an infection that required removal of the initial device, or incorrect placement resulting in poor sensing.
- **Recommended Clinical Approach:** Noninvasive ambulatory ECG monitoring is recommended first in patients with symptoms suggestive of an arrhythmia. Poor diagnostic yield of noninvasive monitoring in the setting of continued symptoms may lead a physician to recommend an ILR for their patient.[1]This is particularly true for patients with unexplained syncope, which is more often due to a bradyarrhythmia event, but could be associated with a ventricular arrhythmic event.[1] This procedure is performed by a trained cardiologist or cardiac electrophysiologist, and referral to a center that supports this service is required.[21,22]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **Implantable Loop Recorder** is considered appropriate if **ALL** of the following is **TRUE**:

◆ The patient has **ANY** of the following[23]:

- Irregular heartbeat.
- Dizziness.
- Shortness of breath.
- Chest discomfort.
- Syncope.
- Hemodynamic collapse.
- Cool or pale extremities.
- Generalized listless affect or signs of mental confusion.
- Irregular size or rate of jugular venous pulsations.
- Palpable liver enlargement.
- Bibasilar rales on lung auscultation.

        - Physical findings suggestive of structural heart disease (e.g., heart murmurs, displaced PMI).
    - ◆ No diagnostic conclusions have been achieved with noninvasive monitoring methods, such as an holter monitor, external loop recorder, or mobile cardiac telemetry.[1,24]
    - ◆ The patient has no other implantable cardiac devices which can detect, record, and transmit data to a physician/cardiologist.
    - ◆ The patient has no active systemic infection or nonreversible bleeding disorder, which would create a safety contraindication.

Non-Indications

- ➔ **Implantable Loop Recorders** is not considered appropriate if **ANY** of the following is **TRUE**:
    - ◆ The patient does not have any positive clinical risk factors, presentation or history findings, or physical exam findings pertinent to remote ECG monitoring.
    - ◆ The patient has a culprit arrhythmic diagnosis identified on noninvasive monitoring.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
33285	Insertion and programming of subcutaneous cardiac rhythm monitor
33286	Removal of subcutaneous cardiac rhythm monitor

Service: External Wearable Devices

General Guidelines

- **Units, Frequency, & Duration:** When medical necessity is met based on described clinical criteria, and exclusionary criteria are absent, noninvasive external cardiac monitoring may be conducted using external wearable devices for 24 hours to 30 days, depending on symptom frequency.
- **Criteria for Subsequent Requests:** Subsequent requests are appropriate for follow-up monitoring of a chronic or progressive cardiac rhythm abnormality. They may also be considered for device malfunction, high burden of poor quality data/artifact, or inability to record patient symptoms.
- **Recommended Clinical Approach:** With evidence of frequent PVCs or more sustained ventricular tachycardia based on clinical history, physical exam, and 12-lead ECG, the most appropriate external wearable monitor should be selected based on patient symptom frequency and suspected duration of the episodes. Daily symptoms and assessment of PVC burden may be addressable with a 24-48 hour Holter monitor. However, in patients with syncope of uncertain origin, Holter monitoring only yielded a significant bradyarrhythmia in 11% of studies.[24] Less frequent or asymptomatic events are more likely to be captured with longer duration monitoring, either a 30-day loop recorder, cardiac mobile telemetry, or an extended-wear patch device. Consideration of the patient's ability to trigger a device effectively may also guide device selection in favor of those with more passive event recording capability.[24,25,26,27]
- **Exclusions:** Two types of monitors cannot be ordered simultaneously.

Medical Necessity Criteria

Indications

➔ **External Wearable Device** is considered appropriate if **ANY** of the following is **TRUE**[27]:

- ◆ The frequency of symptoms suspected to be due to a ventricular arrhythmia occurs within a 3-week period.
- ◆ For diagnostic surveillance of premature ventricular beat burden.[1]
- ◆ If the patient has had 3 or more external wearable devices in the last six months, consider an internal loop recorder.

Non-Indications

- ➔ **External Wearable Device** is not considered appropriate if **ANY** of the following is **TRUE**[27]:
  - ◆ When bradycardia is associated with symptoms suggestive of angina or clinically significant coronary artery obstruction, and monitoring would delay other needed testing or intervention.
  - ◆ The patient has an existing pacemaker or internal loop recorder capable of acquiring clinical data of a similar or equivalent quality to an external cardiac monitor.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
93228	Other qualified health care professional review and interpretation with report of external mobile cardiovascular telemetry with electrocardiographic recording, concurrent computerized real time data analysis, and greater than 24 hours of accessible electrocardiogram (ECG) data storage (retrievable with query) with ECG triggered and patient selected events transmitted to a remote attended surveillance center for up to 30 days
93229	Technical support for connection and patient instructions for use, attended surveillance for up to 30 days, analysis and other qualified health care professional prescribed transmission of daily and emergent data reports of external mobile cardiovascular telemetry with electrocardiographic recording, concurrent computerized real time data analysis, and greater than 24 hours of accessible electrocardiogram (ECG) data storage (retrievable with query) with ECG triggered and patient selected events transmitted to a remote attended surveillance center

Non-Invasive Testing

Service: Computed Tomography Angiography (CTA), Cardiac

General Guidelines

- **Units, Frequency, & Duration:** Single request based on medical necessity criteria.
- **Criteria for Subsequent Requests:** New indication or follow-up after an intervention.
- **Recommended Clinical Approach:** Cardiac CTA is useful in the setting of structural abnormalities and assessment of structural heart disease, that may impact management strategy, including factors that may influence the approach to cardiac ablation or implantation of a pacemaker or defibrillator. Angiography as an adjunct imaging protocol is also useful in understanding anatomic features, especially vascular anatomy. However, cardiac CTA is not a sensitive imaging modality for assessing myocardial disease, often associated with ventricular arrhythmias. In the case of myocarditis, fibrosis quantification related to hypertrophic cardiomyopathy or infiltrative disease, surgical scarring, or assessment of prior infarct, MRI/MRA is a much more valuable technique.[1,6,11,28]
- **Exclusions:** Cardiac CTA for evaluation for cardiac anatomic evaluations may not include other study protocols, e.g., calcium scoring (CAS) or CCTA, which may require a different diagnostic indication.

Medical Necessity Criteria

Indications

➔ **Cardiac CTA** is considered appropriate if **ANY** of the following is **TRUE**[28]:

- ◆ As an imaging modality in a patient with ventricular arrhythmias and suspected structural heart disease where other imaging modalities have not defined anatomical structures successfully.
- ◆ To assess cardiac function (i.e., ejection fraction) in patient evaluation for ICD implant.
- ◆ For pre-procedural evaluation of cardiac anatomy for appropriate planning of pacing or defibrillator system implantation.

Non-Indications

➔ **Cardiac CTA** is not may not be considered appropriate if **ANY** of the following is **TRUE**[28]:

- When an MRI has recently been requested for the same indications.
- Non-rate-controlled atrial fibrillation.
- Impaired renal function because angiographic contrast is utilized for the study.
- Contrast dye hypersensitivity.
- The patient uses metformin.
- In pregnant patients.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
75572	Computed tomography (CT) of heart with contrast material for evaluation of cardiac structure and morphology, including 3-dimensional (3D) image postprocessing, assessment of cardiac function, and evaluation of venous structures
75573	Computed tomography (CT) of heart with contrast material for evaluation of cardiac structure and morphology in congenital heart disease

Service: Coronary Computed Tomography Angiography (CCTA)

General Guidelines

- **Units, Frequency, & Duration:** Single instance as guided by medical necessity criteria.
- **Criteria for Subsequent Requests:** For periodic surveillance of coronary artery lesions or new clinical indications.
- **Recommended Clinical Approach:** Coronary computed tomography angiography is a specific anatomic evaluation for coronary artery anatomy and quantification of obstructive coronary lesions. It is a test that has high sensitivity in the identification of plaques. It also has a high negative predictive value for screening patients at lower to moderate risk of CAD. This is a test that is increasingly performed for screening patients in the outpatient setting for CAD. It can be a complimentary evaluation with stress testing and can serve as an alternative diagnostic tool in equivocal or uninterpretable stress testing results. The use of noninvasive fractional flow reserve (FFR) following a positive CCTA may be considered medically necessary to guide decisions about the use of invasive coronary angiography in patients with 40-90% stenosed coronary lesions on CCTA.[10,29,30,31]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **CCTA** is considered appropriate if **ANY** of the following is **TRUE**[31]:
- ◆ The patient is symptomatic for possible CAD (chest pain or ischemic equivalent) with an intermediate to high pre-test probability.[8,9]
- ◆ For preoperative assessment for planned non-coronary cardiac surgeries, including valvular heart disease, congenital heart disease, and pericardial disease, in lieu of cardiac catheterization.
- ◆ For evaluation of coronary anatomy in suspected coronary anomalies in young persons.

Non-Indications

➔ **CCTA** may not be considered appropriate if **ANY** of the following is **TRUE**[31]:
- ◆ Non-rate controlled atrial fibrillation.
- ◆ Impaired renal function because angiographic contrast is utilized for the study.

- Contrast dye hypersensitivity.
- The patient uses metformin.
- In pregnant patients.[32]
- Normal coronary angiogram or CCTA with no stenosis or plaque within the last two years.
- Normal stress test (given adequate stress) within the last year.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
75574	Computed tomographic angiography, heart, coronary arteries and bypass grafts (when present), with contrast material, including 3D image postprocessing (including evaluation of cardiac structure and morphology, assessment of cardiac function, and evaluation of venous structures, if performed.

Service: Fractional Flow Reserve (CT-FFR)

General Guidelines

Units, Frequency, & Duration: Single instance and must be ordered in conjunction with coronary CTA imaging.
Criteria for Subsequent Requests: For periodic surveillance of coronary artery lesions or new clinical indications.
Recommended Clinical Approach: The use of noninvasive fractional flow reserve (FFR) following a positive CCTA may be considered medically necessary to guide decisions about invasive coronary angiography in patients with intermediate to high-risk coronary lesions on CCTA.[10,33]
Exclusions: As sinus node dysfunction is not directly related to atherosclerotic disease (the sinus nodal artery is not prone to ischemia), noninvasive fractional flow reserve (CT-FFR) is not a typical study in the workup of sinus node dysfunction.

Medical Necessity Criteria

Indications

- ➔ **FFR***** is considered appropriate if **ANY** of the following is **TRUE**[34]:
  - For functional evaluation of coronary CTA lesions which are 40-90% stenosed in a proximal to a middle coronary segment on CCTA.[10,35]
  - For evaluation of multivessel disease to identify culprit lesions causing symptoms.
  - For evaluation of multiple lesions in a single vessel to evaluate physiologic severity.[29,30,35]

***FFR can only be requested with a coronary CTA or after a recently performed coronary CTA

Non-Indications

- ➔ **FFR** is not appropriate if **ANY** of the following conditions is **TRUE**[36]:
  - Original CCTA was of suboptimal quality.
  - The patient is not a candidate for revascularization.[35]
  - The patient is post coronary artery bypass surgery.
  - The patient has a metal intracoronary stent in the vessel to be studied.[35]
  - Coronary anatomy that is low risk (is less than 40% stenosed).
  - In complex congenital heart disease.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
0501T	Noninvasive estimated coronary fractional flow reserve (FFR) derived from coronary computed tomography angiography data using computation fluid dynamics physiologic simulation software analysis of functional data to assess the severity of coronary artery disease.
0502T	Noninvasive estimated coronary fractional flow reserve (FFR) derived from coronary computed tomography angiography data using computation fluid dynamics physiologic simulation software analysis of functional data to assess the severity of coronary artery disease; data preparation and transmission
0503T	Noninvasive estimated coronary fractional flow reserve (FFR) derived from coronary computed tomography angiography data using computation fluid dynamics physiologic simulation software analysis of functional data to assess the severity of coronary artery disease; analysis of fluid dynamics and simulated maximal coronary hyperemia, and generation of estimated FFR model
0504T	Noninvasive estimated coronary fractional flow reserve (FFR) derived from coronary computed tomography angiography data using computation fluid dynamics physiologic simulation software analysis of functional data to assess the severity of coronary artery disease; anatomical data review in comparison with estimated FFR model to reconcile discordant data, interpretation and report
0523T	Intraprocedural coronary fractional flow reserve (FFR) with 3D functional mapping of color-coded FFR values for the coronary tree, derived from coronary angiogram data, for real-time review and interpretation of possible atherosclerotic stenosis(es) intervention (List separately in addition to code for primary procedure)

Service: Cardiac Positron Emission Tomography (Cardiac PET)

General Guidelines

- **Units, Frequency, & Duration:** None.
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** POSITRON EMISSION TOMOGRAPHY (PET) is a minimally invasive diagnostic imaging procedure used to evaluate metabolism in normal tissues and diseased tissues in conditions such as cancer, ischemic heart disease, and infiltrative cardiac diseases such as sarcoidosis or amyloidosis.[37] The benefits of PET scans include greater accuracy for patients who cannot adequately exercise and less radiation exposure than SPECT. It is particularly beneficial in obese patients and others prone to SPECT attenuation artifact, in younger patients (men less than 40 years of age, women less than 50 years of age) to reduce radiation exposure compared to SPECT and following equivocal or nondiagnostic testing.
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **Cardiac PET** is considered appropriate if **ANY** of the following is **TRUE**[10]:
- ◆ For initial and follow-up studies to diagnose and track the progression of cardiac amyloidosis or sarcoidosis.38
- ◆ The patient has **ALL** of the following:
  - Symptoms of CAD (chest pain or ischemic equivalent) and intermediate or high pre-test probability of CAD.[8,9]
  - If the patient has **ANY** of the following:
    - Likely to experience attenuation artifact with SPECT imaging due to factors such as morbid obesity, large breasts, breast implants, previous mastectomy, chest wall deformity, pleural/pericardial effusion;
    - Previous inadequate SPECT/MPI imaging due to inadequate findings, technical difficulties with interpretation, or discordant results with previous clinical data.

Non-Indications

➔ **Cardiac PET** may not be considered appropriate if **ANY** of the following is **TRUE**[38]:

- The patient is pregnant.
- The patient has allergic reactions or intolerance to radiotracers.
- If the assessment is not for cardiac amyloidosis or sarcoidosis, then **ANY** of the following:
  - Normal coronary angiogram or CCTA with no stenosis or plaque within the last two years.
  - Normal stress test (given adequate stress) within the last year.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
78429	Single positron emission tomography (PET) myocardial imaging study for metabolic evaluation with concurrently acquired computed tomography (CT) transmission scan
78430	Single positron emission tomography (PET) myocardial perfusion imaging study with evaluation of ejection fraction, at rest, with concurrently acquired computed tomography (CT) transmission scan
78431	Multiple positron emission tomography (PET) myocardial perfusion imaging studies with evaluation of ejection fraction, at rest, with concurrently acquired computed tomography (CT) transmission scan
78432	Positron emission tomography (PET) combined myocardial perfusion imaging study and metabolic evaluation study using dual radiotracer
78433	Positron emission tomography (PET) combined myocardial perfusion imaging and metabolic evaluation study using dual radiotracer, with concurrently acquired computed tomography (CT) transmission scan
78459	Single positron emission tomography (PET) myocardial imaging study for metabolic evaluation
78491	Single positron emission tomography (PET) myocardial perfusion imaging study with evaluation of ejection fraction, at rest

78492	Multiple positron emission tomography (PET) myocardial perfusion imaging studies with evaluation of ejection fraction, at rest and with exercise stress
78811	Positron emission tomography (PET) imaging of chest
78814	Positron emission tomography (PET) with concurrently acquired computed tomography (CT)
G0235	Pet not otherwise specified
G0252	Pet imaging initial dx

Service: Magnetic Resonance Angiogram (MRA)/Magnetic Resonance Imaging (MRI)

General Guidelines

- **Units, Frequency, & Duration:** None.
- **Criteria for Subsequent Requests:** Considerations of additional phase, dynamic sequences, positioning of the patient, and use of markers at the discretion of the protocoling radiologist.
- **Recommended Clinical Approach:** Cardiac MRI is useful in the setting of acquired or congenital structural abnormalities and assessment of factors that may impact the clinical course and prognosis of ventricular arrhythmias. As an adjunct imaging protocol, magnetic resonance angiography is also useful in understanding anatomic features that may impact the strategy for implantation of a pacemaker or defibrillator. Cardiac MRI with late gadolinium enhancement is particularly useful for studying fibrosis within the myocardium, the extent of which can impact the cardiac conduction system. This is useful in patients with ischemic and nonischemic cardiomyopathies, infiltrative diseases like sarcoidosis or hemochromatosis, lymphomas, intracardiac masses, or past infarction.[1,6]
- **Exclusions:** Exclusions include contraindications of MRI (e.g., retained metal, incompatible width to bore size, claustrophobia), incompatibility with following directions (i.e., breath-hold), and renal insufficiency (eGFR less than 30 mL/min per 1.73 m^2) if gadolinium contrast is requested.

Medical Necessity Criteria

Indications

➔ **MRI/MRA** is considered appropriate if **ANY** of the following is **TRUE**[39,40,41]:

- To assess cardiac function in evaluation for ICD implant.[6]
- For evaluation of the presence or extent of scar or myocardial inflammation.[6]
- For imaging of suspected structural heart disease where echocardiography cannot define anatomical structures fully.
- For pre-procedural evaluation of cardiac anatomy for appropriate planning of pacing system implantation.
- For pre-procedural evaluation for VT ablation

Non-Indications

➔ **MRI/MRA** may not be considered appropriate if **ANY** of the following is **TRUE**[39,40,42]:

- Simultaneous or recent cardiac CT scan for the same indication.
- Non-compatible implanted devices.
- There is a potential for adverse reactions to contrast media.
- Metallic intraocular foreign bodies.
- Claustrophobia.
- If the patient has renal insufficiency (eGFR less than 30 mL/min per 1.73 m^2) and if gadolinium contrast is requested, an MRI/MRA may not be considered appropriate.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
71550	Magnetic resonance imaging (MRI) of chest without contrast material
71551	Magnetic resonance imaging (MRI) of chest with contrast material
71552	Magnetic resonance imaging (MRI) of chest with contrast material, including noncontrast images and image postprocessing, for evaluation of hilar and mediastinal lymphadenopathy
75557	Cardiac magnetic resonance imaging (MRI) without contrast material, for evaluation of morphology and function
75559	Cardiac magnetic resonance imaging (MRI) with stress imaging, without contrast material, for evaluation of morphology and function
75561	Cardiac magnetic resonance imaging (MRI) without contrast material, followed by contrast material and further sequences, for evaluation of morphology and function
75563	Cardiac magnetic resonance imaging (MRI) with stress imaging, without contrast material, followed by contrast material and further sequences, for evaluation of morphology and function
71555	Magnetic resonance angiography (MRA) of chest with contrast material
C9762	Cardiac magnetic resonance imaging for morphology and function, quantification of segmental dysfunction; with

	strain imaging
C9763	Cardiac magnetic resonance imaging for morphology and function, quantification of segmental dysfunction; with stress imaging
S8042	Mri low field
C8909	Mra w/cont, chest
C8910	Mra w/o cont, chest
C8911	Mra w/o fol w/cont, chest

Service: Myocardial Perfusion Imaging Single Photon Emission Computed Tomography (MPI-SPECT)

General Guidelines

- **Units, Frequency, & Duration:** Single instance when medical criteria are met.
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** An ECG stress test performed for evaluation of chronotropic incompetence can be accompanied by imaging when there are risk factors of reversible ischemia present. Patients with new findings of non-sustained polymorphic VT or PVCs with additional comorbidities like hypertension, diabetes, or hyperlipidemia are candidates for stress testing with imaging. An MPI-SPECT can be accomplished using either exercise or pharmacologic agents to simulate the effects of exercise.[34,43]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **MPI-SPECT** is considered appropriate if **ANY** of the following is **TRUE**:
- ◆ Patients who have symptoms (chest pain or ischemic equivalent) and clinical history suggesting an intermediate or high pre-test likelihood of CAD.[8,9]
- ◆ For evaluation of ischemic triggers for VT/VF in ischemic cardiomyopathy.[6]
- ◆ Patients who have clinical suspicion for inducible conduction abnormalities related to ischemia.

Non-Indications

➔ **MPI-SPECT** may not be considered appropriate if **ANY** of the following is **TRUE**[38,44]:
- ◆ The patient is pregnant.
- ◆ If the assessment is not for ischemic triggers for VT/VF or inducible conduction abnormalities, then **ANY** of the following:
  - Normal coronary angiogram or CCTA with no stenosis or plaque within the last two years.
  - Normal stress test (given adequate stress) within the last year.

- An active cardiac condition that has not been stabilized (e.g., uncontrolled hypertension, uncontrolled arrhythmias, undiagnosed chest pain).
- An active pulmonary condition that has not been stabilized (e.g., difficulty breathing, the possibility of pulmonary embolism).
- Vasodilators (i.e., adenosine, regadenoson, and dipyridamole) are contraindicated in patients with hypotension, sinus node dysfunction, high-degree atrioventricular (AV) block (in the absence of back up pacemaker capability), and reactive airway disease.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
78451	Single-photon emission computed tomography (SPECT) myocardial perfusion imaging study with stress
78452	Multiple single-photon emission computed tomography (SPECT) myocardial perfusion imaging studies with stress
78494	Cardiac blood pool single photon emission computed tomography (SPECT) imaging, gated equilibrium study, at rest, with wall motion study plus ejection fraction
78453	Single planar myocardial perfusion imaging study at rest
78454	Multiple planar myocardial perfusion imaging studies with stress
78469	Planar and single photon emission computed tomography (SPECT) myocardial imaging
78481	Single planar cardiac blood pool imaging study by first pass technique with exercise and pharmacological stress, wall motion study plus ejection fraction, with quantification
78483	Multiple planar cardiac blood pool imaging studies by first pass technique with exercise and pharmacological stress, wall motion study plus ejection fraction

Service: Stress Echocardiogram

General Guidelines

- **Units, Frequency, & Duration:** Single instance when medical criteria are met.
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** An ECG stress test which is being performed for evaluation of the response of ventricular arrhythmias to exercise can be accompanied by imaging when there are risk factors of reversible ischemia present. Stress echocardiography can also be used to evaluate left ventricular outflow obstruction caused by hypertrophic cardiomyopathy. Patients with comorbidities like hypertension, diabetes, or hyperlipidemia are candidates for stress testing with imaging. A stress echocardiogram can be accomplished using either exercise or pharmacologic agents (predominantly dobutamine) as the stress mechanism.[45]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **Stress echo** is considered appropriate if **ANY** of the following is **TRUE**:
- ◆ Patients who have ventricular arrhythmias and clinical history (chest pain or ischemic equivalent) suggesting an intermediate or high pre-test likelihood of CAD.[8,9]
- ◆ For evaluation of ischemic triggers for VT/VF in ischemic cardiomyopathy.[6]
- ◆ Patients who have clinical suspicion for inducible conduction abnormalities related to ischemia.

Non-Indications

➔ **Stress echo** may not be considered appropriate if **ANY** of the following is **TRUE**[46]:
- ◆ If the assessment is not for ischemic triggers for VT/VF or inducible conduction abnormalities, then **ANY** of the following:
  - Normal coronary angiogram or CCTA with no stenosis or plaque within the last two years.
  - Normal stress test (given adequate stress) within the last year.

- An active cardiac condition that has not been stabilized (e.g., uncontrolled hypertension, uncontrolled arrhythmias, undiagnosed chest pain).
- An active pulmonary condition that has not been stabilized (e.g., difficulty breathing, the possibility of pulmonary embolism).

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
93350	Real time transthoracic echocardiography with 2-dimensional (2D) image documentation during rest and cardiovascular stress test using treadmill and pharmacologically induced stress, with interpretation and report
93351	Real time transthoracic echocardiography with 2-dimensional (2D) image documentation during rest and cardiovascular stress test using treadmill, bicycle exercise and pharmacologically induced stress, with interpretation and report, including performance of continuous electrocardiographic monitoring, with physician supervision
C8928	Tte w or w/o fol w/con,stres
C8930	Tte w or w/o contr, cont ecg

Service: Transesophageal Echocardiogram (TEE)

General Guidelines

- **Units, Frequency, & Duration:** Single procedures performed as needed for defined criteria.
- **Criteria for Subsequent Requests:** Based on subsequent events as described in medical necessity criteria.
- **Recommended Clinical Approach:** Transesophageal echocardiography is utilized for a more comprehensive evaluation of cardiac anatomy when transthoracic imaging is suboptimal. TEE is also useful in evaluating other heart structures, including better imaging of the mitral valve and the atrial septum. Accurate imaging of structures in the posterior of the heart has clinical significance for a patient who may require intervention for hemodynamic abnormalities related to ventricular arrhythmias. This imaging is usually performed by a dedicated cardiac sonographer and a trained cardiologist.[47]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **TEE** is considered appropriate if **ANY** of the following conditions is **TRUE**:
- For evaluation of structural heart disease not defined by TTE.
- Diminished left ventricular function or dilated cardiomyopathy before a VT ablation to rule out intracardiac thrombus.[47]
- As a follow-up procedure, if initial imaging yielded an intracardiac thrombus or evidence of left atrial stasis (spontaneous contrast) and the patient has had a minimum of 4 weeks of therapeutic anticoagulant therapy.

Non-Indications

➔ **TEE** may not be considered appropriate if **ANY** of the following is **TRUE**:[47]
- Another imaging modality (e.g., CT, MRI) is requested simultaneously to evaluate for intracardiac thrombus.
- The patient has a history of esophageal pathology (stricture, fistula, diverticulum, or laceration, esophageal malignancy, recent surgery of the esophagus, active upper GI bleeding, esophageal varices (relative), or prior esophageal surgery (relative).
- The patient has a history of undiagnosed dysphagia.

Site of Service Criteria

Inpatient, outpatient, or observation status apply.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
93312	Real time transesophageal echocardiography with 2-dimensional (2D) image documentation, M-mode recording, probe placement, image acquisition, interpretation, and report
93313	Real time transesophageal echocardiography with 2-dimensional (2D) image documentation and placement of transesophageal probe only
93314	Interpretation and report only of real time transesophageal echocardiography with 2-dimensional (2D) image documentation and image acquisition
93315	Transesophageal echocardiography (TEE) with probe placement, image acquisition, interpretation, and report
93316	Transesophageal echocardiography (TEE) for placement of transesophageal probe only
93317	Interpretation and report only of transesophageal echocardiography (TEE) with image acquisition
93318	Real time transesophageal echocardiography (TEE) with probe placement, 2-dimensional (2D) image acquisition and interpretation
93355	Transesophageal echocardiography (TEE) for guidance of transcatheter closure of left atrial appendage, with quantitative measurements, probe manipulation, interpretation and report
C8925	2d tee w or w/o fol w/con,in
C8926	Tee w or w/o fol w/cont,cong
C8927	Tee w or w/o fol w/cont, mon

Service: Transthoracic Echocardiogram (TTE)

General Guidelines

- **Units, Frequency, & Duration:** Single procedures performed as needed for defined criteria**.**
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** Ventricular arrhythmias can be present in a wide variety of cardiovascular and systemic diseases. As the prognosis and treatment, or structural heart disease can be influenced by ventricular arrhythmias, monitoring of hemodynamic and rhythm abnormalities often occurs together**.** Transthoracic echocardiography is a safe and easily accessible imaging modality to evaluate various cardiomyopathies, ischemic heart disease, valve disorders, and other congenital heart diseases.[48]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **TTE** is considered appropriate if **ANY** of the following is **TRUE**[48]:
- ◆ Suspected or known structural heart disease in the presence of ventricular arrhythmias
- ◆ For pre-procedural evaluation of heart function.

Non-Indications

➔ **TTE** is not considered appropriate if **ANY** of the following is **TRUE**:
- ◆ Echocardiography has no contraindications. Echocardiography may have limited benefit in patients at the extremes of adult body weight because a thick chest wall (in markedly obese patients) or overcrowded ribs (in severely underweight patients) may limit the penetration of ultrasound waves.[48, 49, 50]

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
93303	Complete transthoracic echocardiography for congenital cardiac anomalies
93304	Follow-up transthoracic echocardiography for congenital

	cardiac anomalies
93306	Real time transthoracic echocardiography with 2-dimensional (2D) image documentation, M-mode recording with spectral Doppler echocardiography, and color flow Doppler echocardiography
93307	Complete real time transthoracic echocardiography with 2-dimensional (2D) image documentation
93308	Follow-up real time transthoracic echocardiography with 2-dimensional (2D) image documentation
C8921	Tte w or w/o fol w/cont, com
C8922	Tte w or w/o fol w/cont, f/u
C8923	2d tte w or w/o fol w/con,co
C8924	2d tte w or w/o fol w/con,fu
C8929	Tte w or wo fol wcon,doppler

Non-Surgical Management

Service: Cardiac Rehabilitation

General Guidelines

- **Units, Frequency, & Duration:** Cardiac rehabilitation is generally appropriate for 36 sessions, 60 minutes each, typically over 12 - 18 weeks. Additional sessions can be requested.[51]
- **Criteria for Subsequent Requests:** Current guidelines do not support the need for repeat cardiac rehabilitation in the absence of a new cardiac event.
- **Recommended Clinical Approach:** Cardiac rehabilitation (CR) is an evidence-based intervention that uses patient education, health behavior modification, and exercise training to improve secondary prevention outcomes and is recognized as an integral component of care for patients with cardiovascular disease.[51,52] Referral to CR is recommended within 12 months after a myocardial infarction (MI), percutaneous coronary intervention, or coronary artery bypass graft surgery or in the setting of stable angina or symptomatic peripheral arterial disease (i.e., intermittent claudication). Referral to CR is also recommended after heart valve surgery or cardiac transplantation, or in the setting of chronic heart failure (NYHA Class I-III) with reduced ejection fraction (HFrEF).[51] The effects of cardiac rehabilitation on mortality, cardiovascular events, hospitalizations, or health-related quality of life are less certain in patients with atrial fibrillation, Adult Congenital Heart Disease, and after permanent pacemaker/ICD implantation, but are described as useful by various National and International specialty societies.[53,54,55] Medicare coverage may not be available for these diagnoses.
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **Cardiac Rehabilitation** is considered appropriate if **ANY** of the following is **TRUE** (within 1 year):[54,55,56]

- ◆ Acute myocardial infarction
- ◆ Acute coronary artery syndrome
- ◆ Chronic stable angina
- ◆ Chronic congestive heart failure (NYHA Class I-III, including with LV assist devices)
- ◆ After coronary artery bypass surgery

- After a percutaneous coronary intervention
- After valvular surgery
- Cardiac transplantation
- Symptomatic peripheral arterial disease
- Atrial fibrillation
- Adult Congenital Heart Disease
- After permanent pacemaker/ICD implantation

Non-Indications

➔ **Cardiac Rehabilitation** may not be considered appropriate if **ANY** of the following are present:[56]

- Active unstable angina
- Decompensated cardiac failure
- Active dangerous or complex arrhythmias
- Dissecting aneurysm
- Myocarditis
- Acute pericarditis
- Severe obstruction of the left ventricular outflow tract
- Severe hypertension
- Exertional hypotension or syncope
- Severe orthopedic limitations
- Recent systemic or pulmonary embolus
- Severe or symptomatic aortic stenosis
- Previous cardiac rehabilitation in the absence of a new cardiac event.

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
S9472	Cardiac rehabilitation program, nonphysician provider, per diem
93798	Physician or other qualified healthcare professional services for outpatient cardiac rehabilitation; with continuous ECG monitoring (per session)

Surgical or Interventional Management

Service: Electrophysiology Study (EPS)

General Guidelines

- **Units, Frequency, & Duration:** One instance, as indicated by clinical guidelines.
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** Electrophysiology studies describe the diagnostic studies performed to evaluate the cardiac electrical system, usually before catheter ablation during the same procedure. However, occasionally diagnostic EPS is used to assess risk for life-threatening arrhythmias,[57] especially in the decision-making process for ICD implant.
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **EPS** is considered appropriate if **ANY** of the following is **TRUE**:
- ◆ For evaluation of syncope after myocardial infarction if noninvasive monitoring is unrevealing.
- ◆ In ischemic cardiomyopathy with EF less than or equal to 40% and non-sustained VT to determine inducibility of sustained VT or VF and need for ICD implant.[1]
- ◆ In a patient with ventricular arrhythmias with an indication for invasive evaluation of other conduction diseases.[24]
- ◆ In patients with complex congenital heart disease and **ALL** of the following:
  - **ANY** of the following:
    - nonsustained VT or
    - unexplained syncope who are known to
  - High-risk substrate (e.g., Tetralogy of Fallot, L-looped transposition of the great arteries (L-TGA)) for ventricular arrhythmias.[57]
- ◆ For risk stratification of Brugada Syndrome with spontaneous or induced Type 1 ECG pattern.[15]

Non-Indications

➔ **EPS** is not considered appropriate if **ANY** of the following is **TRUE**:
- ◆ In patients with heart failure and EF less than or equal to 35%, EPS is not recommended for risk assessment for ICD indication.[58]

Site of Service Criteria

Outpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
93600	Bundle of His recording
93602	Intra-atrial recording
93603	Right ventricular recording
93610	Intra-atrial pacing
93612	Intraventricular pacing
93618	Induction of arrhythmia by electrical pacing
93619	Comprehensive electrophysiologic evaluation with insertion and repositioning of multiple electrode catheters, with right atrial pacing and recording, right ventricular pacing and recording, and His bundle recording
93620	Comprehensive electrophysiologic evaluation with insertion and repositioning of multiple electrode catheters, with attempted induction of arrhythmia, with right atrial pacing and recording, right ventricular pacing and recording, and His bundle recording
93624	Electrophysiologic follow-up study with pacing and recording to test effectiveness of therapy with attempted induction of arrhythmia
93631	Intra-operative epicardial and endocardial pacing and mapping to localize the site of tachycardia or zone of slow conduction for surgical correction

Service: Cardiac Ablation

General Guidelines

- **Units, Frequency, & Duration:** Single event, no applicable frequency.
- **Criteria for Subsequent Requests:** Unsuccessful initial procedure or recurrence of arrhythmia.
- **Recommended Clinical Approach:** Catheter ablation of ventricular arrhythmias is a common approach to treatment, especially when the mechanism is refractory to antiarrhythmic therapy. VT can be due to a reentrant mechanism (often related to a scar-mediated circuit) or focal area of excitability. PVCs with a high-frequency burden on monitoring are often the cause of diminished ventricular function, which can be reversed with catheter ablation.[1,59] In certain forms of VT, an epicardial substrate can be identified. This often requires the insertion of a mapping/ablation catheter from a subxiphoid approach to access the area where the arrhythmia originates.[57]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **Cardiac ablation** is considered appropriate if **ANY** of the following is **TRUE**:

- ◆ Symptomatic Premature Ventricular Complexes (PVCs) in a patient refractory to or intolerant to antiarrhythmic therapy.
- ◆ High PVC frequency is associated with symptoms or diminished LV function (LVEF <50%) on cardiac imaging.
- ◆ When a PVC of similar morphology is a trigger for other arrhythmias, such as VF.
- ◆ Frequent PVCs refractory to medical therapy, which are interfering with the effectiveness of biventricular pacing.
- ◆ Sustained symptomatic monomorphic VT in the structurally normal heart.
- ◆ Episodes of VT causing excess appropriate ICD shocks (e.g., in ARVC, Brugada Syndrome, sarcoidosis).
- ◆ Recurrent sustained monomorphic VT in a patient with structural heart disease that is refractory to or intolerant to antiarrhythmic therapy.[57]
- ◆ In cardiomyopathy with VT storm.
- ◆ Sustained monomorphic VT in repaired Tetralogy of Fallot.[59]

- In other forms of adult congenital heart disease (ACHD) with sustained VT, which have undergone appropriate evaluation and treatment for anatomic and hemodynamic etiologies.[59,60]

Non-Indications

➔ **Cardiac ablation** is not considered appropriate if **ANY** of the following is **TRUE:**

- The patient has infrequent nonsustained VT.
- The patient has Torsades de Pointes or other sustained polymorphic VT.
- After the patient has experienced VF arrest.

Site of Service Criteria

Outpatient or observation status.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
93654	Comprehensive electrophysiologic evaluation with insertion and repositioning of multiple electrode catheters, with attempted induction of arrhythmia, with right atrial pacing and recording, with focus of ventricular ectopy
+93655	Intracardiac catheter ablation of a discrete mechanism of arrhythmia which is distinct from the primary ablated mechanism, including repeat diagnostic maneuvers, to treat a spontaneous or induced arrhythmia
+93662	Intracardiac echocardiography during therapeutic/diagnostic intervention, including imaging supervision and interpretation
+93462	Left heart catheterization by transseptal puncture through intact septum or by transapical puncture

Service: Cardiac Catheterization

General Guidelines

- **Units, Frequency, & Duration:** None.
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** Cardiac catheterization in the context of ventricular arrhythmias can be part of an evaluation for underlying myocardial ischemia. Cardiac catheterization can also assess hemodynamic conditions, which cannot be determined with noninvasive testing. [10,61]
- **Exclusions:** Elective cardiac catheterization should be performed at a facility that offers coronary intervention and has the staffing and lab availability for a PCI if indicated.

Medical Necessity Criteria

Indications

➔ **Cardiac catheterization** is considered appropriate if **ANY** of the following is **TRUE**[10,61]:

- ◆ The patient has worsening Canadian Cardiovascular Society class II or higher angina and **ANY** one of the following:
  - The patient is on two or more antianginal medications.
  - The physician can provide documentation on why the patient is not on two or more antianginal medications (i.e., contraindications or adverse effects).
- ◆ Intermediate- or high-risk noninvasive findings and **ANY** of the following:
  - Worsening or limiting ischemic symptoms (e.g., chest pain, chest tightness, chest burning, shoulder pain, left arm pain, jaw pain, shortness of breath).
  - Stable chest pain despite guideline-directed medical treatment (GDMT).
- ◆ New or increasing polymorphic PVC burden or nonsustained VT in a patient with a history or symptoms of CAD.
- ◆ Before a VT ablation procedure, if clinically significant CAD is suspected.
- ◆ After recovery from unexplained sudden cardiac arrest to evaluate for ischemic heart disease.
- ◆ Suspected microvascular disease.
- ◆ For RV angiography and endomyocardial biopsy, if Arrhythmogenic Right Ventricular Cardiomyopathy is suspected, noninvasive studies are inconclusive.[62]

- Before heart surgery, if the patient has **ANY** of the following:
  - Symptoms of angina
  - Objective evidence of ischemia
  - Decreased LV systolic function
  - CAD
  - Coronary risk factors (including men greater than 40 years of age and postmenopausal women)
- Before **ANY** of the following procedures:
  - TAVR
  - For hemodynamic assessment prior to listing for a heart transplant.

Non-Indications

➔ **Cardiac catheterization** may not be appropriate if **ANY** of the following is **TRUE**[61]:

- Acute or chronic kidney disease.
- Coagulopathy.
- Fever or a systemic infection.
- Uncontrolled hypertension.
- Uncompensated heart failure.
- Severe contrast agent allergy.

Site of Service Criteria

Outpatient or observation status.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
93451	Right heart catheterization
93452	Left heart catheterization with intraprocedural injection for left ventriculography
93453	Combined right and left heart catheterization with intraprocedural injection for left ventriculography
93454	Catheter placement in coronary artery for coronary angiography, with intraprocedural injection for coronary angiography, imaging supervision, and interpretation
93455	Catheter placement in coronary artery for coronary angiography, with intraprocedural injection for coronary angiography, imaging supervision, and interpretation, with catheter placement in bypass graft, with intraprocedural injections for bypass graft angiography

93456	Catheter placement in coronary artery for coronary angiography, with intraprocedural injection for coronary angiography, imaging supervision, and interpretation, with right heart catheterization
93457	Catheter placement in coronary artery for coronary angiography, with intraprocedural injection for coronary angiography, imaging supervision, and interpretation, with catheter placement in bypass graft, with intraprocedural injection for bypass graft angiography and right heart catheterization
93458	Catheter placement in coronary artery for coronary angiography, with intraprocedural injection for coronary angiography, imaging supervision, and interpretation, with left heart catheterization, with intraprocedural injection for left ventriculography
93459	Catheter placement in coronary artery for coronary angiography, with intraprocedural injection for coronary angiography, imaging supervision and interpretation, with left heart catheterization, catheter placement in bypass graft, with bypass graft angiography
93460	Catheter placement in coronary artery for coronary angiography, with intraprocedural injection for coronary angiography, imaging supervision, and interpretation, with right and left heart catheterization
93461	Catheter placement in coronary artery for coronary angiography, with intraprocedural injection for coronary angiography, imaging supervision, and interpretation, with right and left heart catheterization, catheter placement in bypass graft, with bypass graft angiography

Service: Percutaneous Coronary Intervention/ Coronary Angioplasty

General Guidelines

- **Units, Frequency, & Duration:** None.
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** This procedure is done during a heart catheterization for a symptomatic, significant coronary artery stenosis or blockage refractory to optimal medical therapy.[63] Significant CAD requiring revascularization is found over 50% of the time in patients greater than 35 years old with out-of-hospital VF arrests. Revascularization is also recommended for patients with CAD and monomorphic VT before an ablation procedure to reduce the likelihood of ischemia during the procedure.
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **PCI/Coronary Angioplasty** is considered appropriate if **ANY** of the following is **TRUE**[63]:

- ◆ Coronary artery lesion with greater than or equal to 70% occlusion of vessel diameter by invasive angiography or greater than 90% occlusion by coronary CTA amenable to revascularization with unacceptable angina despite GDMT or ischemic-related ventricular arrhythmias.
- ◆ Coronary artery lesion with flow ratio of less than or equal to 0.8 by CT-FFR or with invasive FFR measurement.
- ◆ Patient undergoing TAVI with significant left main or proximal CAD with or without angina
- ◆ Patient with supravalvular aortic stenosis and coronary ostial stenosis with anginal symptoms

Non-Indications

None.

Site of Service Criteria

Outpatient or observation status.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition

92920	Percutaneous transluminal coronary angioplasty into single major coronary artery
92928	Percutaneous transcatheter insertion of stent into single major coronary artery
92937	Percutaneous transluminal revascularization of a single coronary artery bypass graft with angioplasty
92943	Percutaneous transluminal revascularization of chronic total occlusion of a single coronary artery branch with atherectomy, angioplasty, and insertion of stent
C9600	Perc drug-el cor stent sing
C9604	Perc d-e cor revasc t cabg s
C9607	Perc d-e cor revasc chro sin

Service: Myocardial Resection

General Guidelines

- **Units, Frequency, & Duration:** None.
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** A left ventricular (LV) aneurysm after a myocardial infarction can contribute to symptoms associated with heart failure (HF), ventricular arrhythmias, or thrombus formation. In cases refractory to conservative treatment, removal of the involved myocardial tissue may be beneficial. Indications for LV aneurysm resection after myocardial infarction complicated by refractory CHF or ventricular arrhythmias are published in various guidelines.[1,64] Surgical reverse-ventricular remodeling (ventricular reconstruction, Batista procedure, SAVER procedure, Dor procedure) does not appear to be of benefit but may be considered in carefully selected patients with heart failure reduced ejection fraction (HFrEF) for specified indications, including refractory HF or refractory ventricular arrhythmias.[65,66] Many insurance carriers consider such procedures investigational due to an apparent lack of clinical benefit. Medicare does not consider the procedure as reasonable and necessary and thus does not provide coverage.[67]
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **Myocardial Resection** is considered appropriate if **ANY** of the following is **TRUE**:

- ◆ If the patient is being considered for an LV aneurysm resection, and **ALL** of the following are true:
  - The patient is being considered for Surgery for LV aneurysm and has **ANY** of the following:[1,64]
    - Refractory heart failure or angina.
    - Ventricular arrhythmias not amenable to drugs or radiofrequency ablation.
    - Recurrent thromboembolism despite appropriate anticoagulant therapy.
- ◆ The patient is being considered for a surgical reverse-ventricular remodeling (ventricular reconstruction, Batista procedure, SAVER procedure, Dor procedure) and **ALL** of the following are true:
  - Patient with HFrEF and **ANY** of the following:

- Refractory HF.
- Refractory ventricular arrhythmias.[65,66]

Non-Indications

➔ **Myocardial Resection** may not be considered appropriate if **ANY** of the following is **TRUE**:

- Surgical reverse-ventricular remodeling (ventricular reconstruction, Batista procedure, SAVER procedure, Dor procedure) is not indicated for patients with **ALL** of the following:
  - Without documented refractory HF or ventricular arrhythmias.[65,66]

Site of Service Criteria

Inpatient

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
33542	Myocardial resection (e.g., ventricular aneurysmectomy)
33548	Surgical ventricular restoration procedure, includes prosthetic patch, when performed (e.g., ventricular remodeling, SVR, SAVER, Dor procedures)

Service: Cardiac Implantable Device (Defibrillator)

General Guidelines

- **Units, Frequency, & Duration:** One instance, as needed per inclusion criteria.
- **Criteria for Subsequent Requests:** Subsequent requests may be considered for device replacement due to battery end of life (EOL) or elective replacement interval (ERI), replacement after infection, the clinical need for different pacing modes, or replacement after manufacturer recall.
- **Recommended Clinical Approach:** Patients with aborted VF arrest, regardless of etiology, are candidates for the insertion of an implantable cardioverter-defibrillator (ICD) for the secondary prevention of sudden cardiac death.[58] Polymorphic VT in the context of structural heart disease also has a poor prognosis and often has higher rates of appropriate shocks from their ICD. If patients do not require pacing for bradycardia or termination of a tachyarrhythmia, a subcutaneous ICD (vs. transvenous) can be feasible.[1] Transvenous systems have the capabilities of both pacing and defibrillation.
- **Exclusions:** PA requests for a pacemaker alone would not fall under indications for treatment of ventricular arrhythmias. Also, in a patient whose expected remaining lifespan is less than 12 months.

Medical Necessity Criteria

Indications

➔ **Cardiac Implantable Devices (Defibrillator)** are considered appropriate if **ANY** of the following is **TRUE**[58]:

- ◆ After Torsades de Pointes or VF arrest due to suspected cardiac genetic syndrome.
- ◆ For clinical or induced sustained VT in ischemic or nonischemic cardiomyopathy with EF less than or equal to 35%.[1,6]
- ◆ In non-ischemic cardiomyopathy patients, suspected to have arrhythmogenic syncope.
- ◆ For escalation of care of Catecholaminergic Polymorphic VT (CPVT) refractory to beta-blockers alone.
- ◆ In a heart transplant patient with severe vasculopathy and LV dysfunction.[1]
- ◆ In a patient with any congenital heart disease with clinical episodes of sustained VT, VF, or aborted cardiac arrest.
- ◆ In hypertrophic cardiomyopathy (HCM) with **ANY** of the following:

- VT/VF causing cardiac arrest
- Unexplained syncope
- Left ventricular/septal wall thickness greater than or equal to 3 cm
- Spontaneous nonsustained VT
- SCD in a 1st degree relative with HCM
- LVEF <50
- Apical aneurysm
- Extensive (greater than or equal to 15% of LV mass) late gadolinium enhancement (LGE)

◆ In patients with cardiac sarcoidosis and **ANY** of the following:
- EF less than or equal to 35%
- Sustained clinical or induced VT/VF
- Syncope

◆ In patients with repaired Tetralogy of Fallot (TOF) and risk factors for sudden cardiac death including **ANY** of the following[60]:
- left ventricular dysfunction
- sustained, symptomatic ventricular tachycardia
- QRS duration greater than 180 ms
- extensive RV scarring on CMR
- inducible sustained VT at programmed electrical stimulation

Non-Indications

➔ **Cardiac Implantable Devices (Defibrillator)** are not considered appropriate if **ANY** of the following is **TRUE**:
- ◆ In a patient whose expected remaining lifespan is less than 12 months.
- ◆ VT, which is amenable to catheter ablation.
- ◆ In a patient with incessant, drug-refractory VT or VF.
- ◆ Ventricular arrhythmias are due to reversible circumstances, such as electrolyte abnormalities or toxic ingestion.

Site of Service Criteria

Outpatient or Observation.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
33217	Insertion of 2 transvenous electrodes of permanent cardioverter-defibrillator
33230	Insertion of pacing cardioverter-defibrillator pulse generator with connection to existing dual leads

33231	Insertion of pacing cardioverter-defibrillator pulse generator with connection to existing multiple leads
33240	Insertion of pacing cardioverter-defibrillator pulse generator with connection to existing single lead
33244	Transvenous removal of single chamber pacing cardioverter-defibrillator electrode
33249	Insertion of dual chamber permanent pacing cardioverter-defibrillator system with transvenous lead
33262	Removal and replacement of pacing cardioverter-defibrillator pulse generator in single lead system
33263	Removal and replacement of pacing cardioverter-defibrillator pulse generator in dual lead system
33264	Removal and replacement of pacing cardioverter-defibrillator pulse generator in multiple lead system
33270	Insertion of permanent subcutaneous implantable defibrillator system with subcutaneous electrode
33271	Insertion of subcutaneous implantable defibrillator electrode
33272	Removal of subcutaneous implantable defibrillator 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
0573T	Removal of substernal implantable defibrillator electrode
0574T	Repositioning of previously implanted substernal implantable defibrillator-pacing electrode
0577T	Electrophysiologic evaluation of implantable cardioverter-defibrillator system with substernal electrode (includes defibrillation threshold evaluation, induction of arrhythmia, evaluation of sensing for arrhythmia

	termination, and programming or reprogramming of sensing or therapeutic parameters)
0580T	Removal of substernal implantable defibrillator pulse generator only
C1721	Aicd, dual chamber
C1722	Aicd, single chamber
C1777	Lead, aicd, endo single coil
C1882	Aicd, other than sing/dual
C1895	Lead, aicd, endo dual coil
C1899	Lead, pmkr/aicd combination
C1896	Lead, aicd, non sing/dual
0614T	Removal and replacement of substernal implantable defibrillator pulse generator

Service: Wearable Cardioverter-Defibrillator (e.g., LifeVest)

General Guidelines

- **Units, Frequency, & Duration:** One instance, as needed per inclusion criteria.
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** A wearable cardioverter-defibrillator (WCD) is an external device worn as a garment capable of automatic detection and treatment of ventricular tachycardia (VT) or ventricular fibrillation (VF). There are patients at high-risk for ventricular arrhythmias and sudden cardiac death, who should not have an implanted device for the following reasons,[68] and who may be candidates for this type of wearable defibrillator:
    - Susceptibility to life-threatening ventricular arrhythmias may be short-lived.
    - An implanted device may interfere with future interventions (e.g., cardiac transplantation)
    - When a systemic infection prevents insertion of an ICD
- **Exclusions:** Should not be requested if an implantable cardioverter-defibrillator is in place and functional.

Medical Necessity Criteria

Indications

➔ **Wearable Defibrillators** are considered appropriate if **ANY** of the following is **TRUE**[68:]

- ◆ In patients with aborted SCA, when an ICD is inaccessible or transiently contraindicated.
- ◆ In a patient with EF less than or equal to 35% after a recent MI (40 day ICD waiting period)
- ◆ After coronary artery bypass surgery (CABG) or percutaneous coronary intervention with LVEF less than or equal to 40% (90 day ICD waiting period)
- ◆ In patients listed for cardiac transplant.
- ◆ In patients with recently diagnosed nonischemic cardiomyopathy with LVEF less than or equal to 35% (greater than 3 months, up to 9 month, waiting period).[1,69]
- ◆ During an interval when an ICD requires removal (e.g., device pocket infection, endocarditis).[1]

Non-Indications

- ➔ **Wearable Defibrillators** are NOT considered appropriate if ANY of the following is TRUE[68]:
  - ◆ In a patient who is a candidate for an implantable cardioverter-defibrillator (ICD).
  - ◆ In a patient with VT, which is amenable to catheter ablation.
  - ◆ In patients with a terminal disease with a life expectancy of less than one year

Site of Service Criteria

Outpatient or Inpatient.

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
K0606	Automatic external defibrillator, with integrated electrocardiogram analysis, garment type
K0607	Replacement battery for automated external defibrillator, garment type only, each
K0608	Replacement garment for use with automated external defibrillator, each
K0609	Replacement electrodes for use with automated external defibrillator, garment type only, each
93292	Interrogation device evaluation (in person) with analysis, review and report by a physician or other qualified healthcare professional, includes connection, recording and disconnection per patient encounter; wearable defibrillator system
93745	Initial set-up and programming by a physician or other qualified healthcare professional of wearable cardioverter-defibrillator includes initial programming of system, establishing baseline electronic ECG, transmission of data to data repository, patient instruction in wearing system and patient reporting of problems or events

Service: Ventricular Assist Device

General Guidelines

- **Units, Frequency, & Duration:** None.
- **Criteria for Subsequent Requests:** None.
- **Recommended Clinical Approach:** Mechanical Circulatory Support (MCS) may be appropriate to support patients with advanced heart failure with reduced ejection fraction (HFrEF). Technology has progressed to allow MCS to be utilized in a variety of clinical situations involving critically ill patients or high-risk procedures.[70] MCS is characterized in a variety of ways, including expected length of use [short-term (temporary, non-implanted), intermediate to long term (destination, implanted)], ventricle assisted (left, right, both), or physical location of the pumping device (intracorporeal vs extracorporeal). Short-term devices include the intra-aortic balloon pump (IABP), other percutaneous devices (Impella or TandemHeart), extracorporeal mechanical oxygenation (ECMO), and centrifugal pumps used for coronary artery bypass surgery (CABG).[66,71] Contraindications to short-term MCS can vary between devices. Intermediate to long-term devices include the HeartMate II, HeartMate 3, the HeartWare (HVAD) system, which was pulled by the parent company (Medtronic) in mid-2021 over safety concerns), and the SynCardia Total Artificial Heart (TAH).
- **Exclusions:** None.

Medical Necessity Criteria

Indications

➔ **Ventricular Assist Device** is considered appropriate if **ANY** of the following are **TRUE**:[71,72,73]

◆ If the patient is being considered for a short-term or temporary device, and **ANY** of the following are true:

- Adjunct for high-risk percutaneous coronary interventions
- Cardiogenic shock (LV, RV, or both)
- Ischemic mitral regurgitation
- Acute reversible cardiomyopathies (myocarditis, stress cardiomyopathy, peripartum cardiomyopathy)
- Primary cardiac transplant allograft failure due to rejection
- Post-transplant RV failure

- Patients slow to wean from cardiopulmonary bypass following heart surgery
- Refractory arrhythmias

◆ If the patient is being considered for a long-term device and **ALL** of the following are true[73]:

- Patients with HFrEF and persistence of severe (Stage D) symptoms despite optimal medical and device therapy
- Patients without severe right ventricular dysfunction and/or severe tricuspid regurgitation
- The patient has **ANY** of the following:
  - LVEF less than 25% and unable to exercise for Heart Failure or, if able to perform cardiopulmonary exercise testing, with peak VO2 less than 12 mL/kg/min and/or less than 50% predicted value.
  - Greater than or equal to 3 Heart Failure hospitalizations in the previous 12 months without an obvious precipitating cause.
  - Dependence on I.V. inotropic therapy or temporary MCS.
  - Progressive end-organ dysfunction (worsening renal and/or hepatic function, type II pulmonary hypertension, cardiac cachexia) due to reduced perfusion and not to inadequately low ventricular filling pressure (PCWP greater than 20 mmHg and SBP less than 90 mmHg or cardiac index less than 2 L/min/m2).

Non-Indications

➔ **Ventricular Assist Device** may not be considered appropriate if **ANY** of the following is **TRUE**[74]:

◆ If the patient is being considered for a short-term or temporary device, and **ANY** of the following are true:[70]

- Uncontrolled sepsis.
- Bleeding diathesis.
- Severe aortic or PAD.

◆ If the patient is being considered for a long-term device and **ANY** of the following are true:[73]

- A stable psychosocial background is NOT present. (Stable psychosocial background includes demonstrated understanding of the technology, and there is a caregiver in the same household that will help the patient.

- A major contraindication is present (contraindication to long-term oral anticoagulation, infection, severe renal dysfunction, ventricular arrhythmias).

Site of Service Criteria

Inpatient

Procedure Codes (HCPCS/CPT)

HCPCS Code	Code Description/Definition
33995	Insertion of ventricular assist device, percutaneous, including radiological supervision and interpretation; right heart, venous access only
0451T	Insertion or replacement of a permanently implantable aortic counterpulsation ventricular assist system, endovascular approach, and programming of sensing and therapeutic parameters; complete system (counterpulsation device, vascular graft, implantable vascular hemostatic seal, mechano-electrical skin interface and subcutaneous electrodes)
0452T	Insertion or replacement of a permanently implantable aortic counterpulsation ventricular assist system, endovascular approach, and programming of sensing and therapeutic parameters; complete system (counterpulsation device, vascular graft, implantable vascular hemostatic seal, mechano-electrical skin interface and subcutaneous electrodes); aortic counterpulsation device and vascular hemostatic seal
0453T	Insertion or replacement of a permanently implantable aortic counterpulsation ventricular assist system, endovascular approach, and programming of sensing and therapeutic parameters; complete system (counterpulsation device, vascular graft, implantable vascular hemostatic seal, mechano-electrical skin interface and subcutaneous electrodes); mechano-electrical skin interface
0454T	Insertion or replacement of a permanently implantable aortic counterpulsation ventricular assist system, endovascular approach, and programming of sensing and therapeutic parameters; complete system (counterpulsation device, vascular graft, implantable vascular hemostatic seal, mechano-electrical skin interface and subcutaneous electrodes); subcutaneous electrode

0455T	Removal of permanently implantable aortic counterpulsation ventricular assist system; complete system (aortic counterpulsation device, vascular hemostatic seal, mechano-electrical skin interface and electrodes)
0456T	Removal of permanently implantable aortic counterpulsation ventricular assist system; complete system (aortic counterpulsation device, vascular hemostatic seal, mechano-electrical skin interface and electrodes); aortic counterpulsation device and vascular hemostatic seal
0457T	Removal of permanently implantable aortic counterpulsation ventricular assist system; complete system (aortic counterpulsation device, vascular hemostatic seal, mechano-electrical skin interface and electrodes); mechano-electrical skin interface
0458T	Removal of permanently implantable aortic counterpulsation ventricular assist system; complete system (aortic counterpulsation device, vascular hemostatic seal, mechano-electrical skin interface and electrodes); subcutaneous electrode
0459T	Relocation of skin pocket with replacement of implanted aortic counterpulsation ventricular assist device, mechano-electrical skin interface and electrodes
0460T	Repositioning of previously implanted aortic counterpulsation ventricular assist device; subcutaneous electrode
0461T	Repositioning of previously implanted aortic counterpulsation ventricular assist device; subcutaneous electrode; aortic counterpulsation device
0462T	Programming device evaluation (in person) with iterative adjustment of the implantable mechano-electrical skin interface and/or external driver to test the function of the device and select optimal permanent programmed values with analysis, including review and report, implantable aortic counterpulsation ventricular assist system, per day
0463T	Interrogation device evaluation (in person) with analysis, review and report, includes connection, recording and disconnection per patient encounter, implantable aortic counterpulsation ventricular assist system, per day
Q0477	Pwr module pt cable lvad rpl
Q0480	Driver pneumatic vad, rep
Q0481	Microprcsr cu elec vad, rep

Q0482	Microprcsr cu combo vad, rep
Q0483	Monitor elec vad, rep
Q0484	Monitor elec or comb vad rep
Q0485	Monitor cable elec vad, rep
Q0486	Mon cable elec/pneum vad rep
Q0487	Leads any type vad, rep only
Q0488	Pwr pack base elec vad, rep
Q0489	Pwr pck base combo vad, rep
Q0490	Emr pwr source elec vad, rep
Q0491	Emr pwr source combo vad rep
Q0492	Emr pwr cbl elec vad, rep
Q0493	Emr pwr cbl combo vad, rep
Q0494	Emr hd pmp elec/combo, rep
Q0495	Charger elec/combo vad, rep
Q0496	Battery elec/combo vad, rep
Q0497	Bat clps elec/comb vad, rep
Q0498	Holster elec/combo vad, rep
Q0499	Belt/vest elec/combo vad rep
Q0500	Filters elec/combo vad, rep
Q0501	Shwr cov elec/combo vad, rep
Q0502	Mobility cart pneum vad, rep
Q0503	Battery pneum vad replacemnt
Q0504	Pwr adpt pneum vad, rep veh
Q0505	#N/A
Q0506	Lith-ion batt elec/pneum vad
Q0507	Misc sup/acc ext vad
Q0508	Mis sup/acc imp vad
Q0509	Mis sup/ac imp vad nopay med
33975	Insertion of extracorporeal single ventricle ventricular assist device
33976	Insertion of extracorporeal biventricular assist device
33977	Removal of extracorporeal single ventricle ventricular assist device

33978	Removal of extracorporeal biventricular assist device
33979	Insertion of implantable intracorporeal single ventricle ventricular assist device
33980	Removal of implantable intracorporeal single ventricle ventricular assist device
33981	Replacement of pump of extracorporeal biventricular assist device
33982	Replacement of pump of implantable intracorporeal single-ventricle ventricular assist device
33983	Replacement of pump of implantable intracorporeal single ventricle ventricular assist device with cardiopulmonary bypass
33992	Removal of percutaneous ventricular assist device at separate and distinct session from insertion

Surgical Risk Factors

Patient Medical Risk Stratification

Patient Risk Score	Patient Characteristic	Min Range	Max Range	Guidance
1- Very Low Risk	No known medical problems			
2- Low Risk	Hypertension		180/110 mm Hg	
2- Low Risk	Asthma	peak flow >80% of predicted or personal best value		
2- Low Risk	Prior history of alcohol abuse			Screen for liver disease and malnutrition
2- Low Risk	Prior history of tobacco use			
3- Intermediate Risk	Asthma	peak flow <80% of predicted or personal best value		
3- Intermediate Risk	Active alcohol abuse			
3- Intermediate Risk	Age	65	75	
3- Intermediate Risk	History of treated, stable coronary artery disease (CAD)			
3- Intermediate Risk	Stable atrial fibrillation			
3- Intermediate Risk	Diabetes mellitus	HbA1C >7%		
3- Intermediate Risk	Morbid obesity	BMI 30	BMI 40	
3- Intermediate Risk	Anemia	hemoglobin <11 (females), <12 (males)		Workup to identify etiology
3- Intermediate Risk	HIV	CD4 <200 cells/mm3		Get clearance from HIV specialist
3- Intermediate Risk	Rheumatologic disease			Preoperative consultation with rheumatologist re: perioperative medication management
3- Intermediate Risk	Peripheral vascular disease or history of peripheral vascular bypass	ankle-brachial pressure index (ABPI) <0.9		Preoperative consultation with vascular surgeon

3- Intermediate Risk	History of venous thromboembolism (VTE)			
3- Intermediate Risk	Well-controlled obstructive sleep apnea			
3- Intermediate Risk	Malnutrition	transferrin <200 mg/dL albumin <3.5 g/dL prealbumin <22.5 mg/dL total lymphocyte count <1200-1500 cell/mm3 BMI <18		Preoperative consultation with nutritionist
3- Intermediate Risk	Active tobacco Use			Enroll patient in smoking cessation program
3- Intermediate Risk	Known allergy or hypersensitivity to medication needed for procedure			
4- High Risk	Advanced Renal Disease (Creatinine > 2)			
4- High Risk	Diabetes mellitus with complications	HbA1c >8%		
4- High Risk	Age	76	85	
4- High Risk	Oxygen dependent pulmonary disease			
4- High Risk	Sickle cell anemia			
4- High Risk	Obesity	BMI 40		
4- High Risk	Cirrhosis, history of hepatic decompensation or variceal bleeding			
4- High Risk	Impaired cognition; dementia			
4- High Risk	Compensated CHF			
4- High Risk	Cerebrovascular disease			
4- High Risk	Uncontrolled or suspected obstructive sleep apnea (OSA)			
4- High Risk	Renal insufficiency	serum creatinine >1.5 mg/dL or creatinine clearance <100 mL/min		

4- High Risk	Opioid dependence			
5- Very High Risk	Percutaneous Coronary Intervention (PCI) within 1 month			
5- Very High Risk	Cardiovascular: unstable angina, recent myocardial infarction (60 days), uncontrolled atrial fibrillation or other high-grade abnormal rhythm, severe valvular disease, decompensated heart failure			
5- Very High Risk	Primary pulmonary hypertension			Preoperative consultation with pulmonologist warranted
5- Very High Risk	Cirrhosis or severe liver disease, history of hepatic decompensation or variceal bleeding			
5- Very High Risk	Severe frailty, dependence for ADLs, or history of 3 or more falls in last 6 mos			
5- Very High Risk	Obesity		BMI >50	
5- Very High Risk	Age		>85	
5- Very High Risk	History of VTE with CI to anticoagulation, failure of anticoagulation, cessation of anticoagulation therapy secondary to bleeding			Preoperative consultation with hematologist or internist
5- Very High Risk	Renal failure requiring dialysis			
5- Very High Risk	Immunosuppression			
5- Very High Risk	Chronic Pain			

References

1. Al-Khatib SM, Stevenson WG, Ackerman MJ, Bryant WJ, Callans DJ, Curtis AB, Deal BJ, Dickfeld T, Field ME, Fonarow GC, Gillis AM, Granger CB, Hammill SC, Hlatky MA, Joglar JA, Kay GN, Matlock DD, Myerburg RJ, Page RL. 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: Executive summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. Heart Rhythm. 2018 Oct;15(10):e190-e252.
2. Kim J, Kwon M, Chang J, Harris D, Gerson MC, Hwang SS, Oh SW. Meta-Analysis of Prognostic Implications of Exercise-Induced Ventricular Premature Complexes in the General Population. Am J Cardiol. 2016 Sep 1;118(5):725-32.
3. Lee GK, Klarich KW, Grogan M, Cha YM. Premature ventricular contraction-induced cardiomyopathy: a treatable condition. Circ Arrhythm Electrophysiol. 2012 Feb;5(1):229-36.
4. Ataklte F, Erqou S, Laukkanen J, Kaptoge S. Meta-analysis of ventricular premature complexes and their relation to cardiac mortality in general populations. Am J Cardiol. 2013 Oct 15;112(8):1263-70.
5. Gupta S, Pressman GS, Figueredo VM. Incidence of, predictors for, and mortality associated with malignant ventricular arrhythmias in non-ST elevation myocardial infarction patients. Coron. Artery Dis. 2010;21:460–5.
6. Nielsen JC, Lin YJ, de Oliveira Figueiredo MJ, Sepehri Shamloo A, Alfie A, Boveda S, Dagres N, Di Toro D, Eckhardt LL, Ellenbogen K, Hardy C, Ikeda T, Jaswal A, Kaufman E, Krahn A, Kusano K, Kutyifa V, S Lim H, Lip GYH, Nava-Townsend S, Pak HN, Rodríguez Diez G, Sauer W, Saxena A, Svendsen JH, Vanegas D, Vaseghi M, Wilde A, Bunch TJ, Buxton AE, Calvimontes G, Chao TF, Eckardt L, Estner H, Gillis AM, Isa R, Kautzner J, Maury P, Moss JD, Nam GB, Olshansky B, Molano LFP, Pimentel M, Prabhu M, Tzou WS, Sommer P, Swampillai J, Vidal A, Deneke T, Hindricks G, Leclercq C. European Heart Rhythm Association (EHRA)/Heart Rhythm Society (HRS)/Asia Pacific Heart Rhythm Society (APHRS)/Latin American Heart Rhythm Society (LAHRS) expert consensus on risk assessment in cardiac arrhythmias: use the right tool for the right outcome, in the right population. J Arrhythm. 2020 Jun 15;36(4):553-607.
7. Junttila MJ, Hookana E, Kaikkonen KS, et al. Temporal trends in the clinical and pathological characteristics of victims of sudden cardiac death in the absence of previously identified heart disease. Circ Arrhythm Electrophysiol. 2016;9:e003723.

8. Genders TS, Steyerberg EW, Alkadhi H, et al. A clinical prediction rule for the diagnosis of coronary artery disease: validation, updating, and extension. *Eur Heart J*. 2011;32(11):1316-1330. doi:10.1093/eurheartj/ehr014
9. Knuuti J, Wijns W, Saraste A, et al. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes [published correction appears in Eur Heart J. 2020 Nov 21;41(44):4242]. Eur Heart J. 2020;41(3):407-477. doi:10.1093/eurheartj/ehz425
10. Gulati M, Levy PD, Mukherjee D, et al. 2021 AHA/ACC/ASE/Chest/Saem/SCCT/SCMR guideline for the evaluation and diagnosis of chest pain. Journal of the American College of Cardiology. October 2021. doi:10.1016/j.jacc.2021.07.053
11. Reviriego SM, Merino JL. Short SQ Syndrome. *ESC Council for Cardiology Practice (ESC)*. 2010;9(2).
12. Behere SP, Weindling SN. Inherited arrhythmias: The cardiac channelopathies. *Ann Pediatr Cardiol*. 2015;8(3):210-220. doi:10.4103/0974-2069.164695
13. Musunuru K, Hershberger RE, Day SM, et al. Genetic Testing for Inherited Cardiovascular Diseases: A Scientific Statement From the American Heart Association. Circ Genom Precis Med. 2020;13(4):e000067. doi:10.1161/HCG.0000000000000067
14. Giudicessi JR, Ackerman MJ. Genetic testing in heritable cardiac arrhythmia syndromes: differentiating pathogenic mutations from background genetic noise. Curr Opin Cardiol. 2013;28(1):63-71. doi:10.1097/HCO.0b013e32835b0a41
15. Honarbakhsh S, Providencia R, Garcia-Hernandez J, Martin CA, Hunter RJ, Lim WY, Kirkby C, Graham AJ, Sharifzadehgan A, Waldmann V, Marijon E, Munoz-Esparza C, Lacunza J, Gimeno-Blanes JR, Ankou B, Chevalier P, Antonio N, Elvas L, Castelletti S, Crotti L, Schwartz P, Scanavacca M, Darrieux F, Sacilotto L, Mueller-Leisse J, Veltmann C, Vicentini A, Demarchi A, Cortez-Dias N, Antonio PS, de Sousa J, Adragao P, Cavaco D, Costa FM, Khoueiry Z, Boveda S, Sousa MJ, Jebberi Z, Heck P, Mehta S, Conte G, Ozkartal T, Auricchio A, Lowe MD, Schilling RJ, Prieto-Merino D, Lambiase PD; Brugada Syndrome Risk Investigators. A Primary Prevention Clinical Risk Score Model for Patients With Brugada Syndrome (BRUGADA-RISK). JACC Clin Electrophysiol. 2021 Feb;7(2):210-222.
16. Lymperopoulos A, McCrink KA, Brill A. Impact of CYP2D6 Genetic Variation on the Response of the Cardiovascular Patient to Carvedilol and Metoprolol. Curr Drug Metab. 2015;17(1):30-36. doi:10.2174/1389200217666151105125425
17. Sunthankar SD, Kannankeril PJ, Gaedigk A, Radbill AE, Fish FA, Van Driest SL. Influence of CYP2D6 genetic variation on adverse events with propafenone in the pediatric and young adult population. Clin Transl Sci. 2022;15(7):1787-1795. doi:10.1111/cts.13296

18. Taylor C, Crosby I, Yip V, Maguire P, Pirmohamed M, Turner RM. A Review of the Important Role of CYP2D6 in Pharmacogenomics. Genes (Basel). 2020;11(11):1295. Published 2020 Oct 30. doi:10.3390/genes11111295
19. Voora D, S. Ginsburg G. Clinical Application of Cardiovascular Pharmacogenetics. Journal of the American College of Cardiology, Vol. 60, No. 1, 2012. http://dx.doi.org/10.1016/j.jacc.2012.01.067.
20. Galli A, Ambrosini F, Lombardi F. Holter Monitoring and Loop Recorders: From Research to Clinical Practice. Arrhythm Electrophysiol Rev. 2016;5(2):136-143. doi:10.15420/AER.2016.17.2
21. Sakhi R, Theuns DAMJ, Szili-Torok T, Yap SC. Insertable cardiac monitors: current indications and devices. Expert Rev Med Devices. 2019;16(1):45-55. doi:10.1080/17434440.2018.1557046
22. Writing Group Members, January CT, Wann LS, Calkins H, Chen LY, Cigarroa JE, Cleveland JC Jr, Ellinor PT, Ezekowitz MD, Field ME, Furie KL, Heidenreich PA, Murray KT, Shea JB, Tracy CM, Yancy CW. 2019 AHA/ACC/HRS focused update of the 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society
23. Kwok CS, Darlington D, Mayer J, Panchal G, Walker V, et al. A review of the wide range of indications and uses of implantable loop recorders: a review of the literature. Hearts 2022,3,45-53. https://doi.org/10.3390/hearts3020007
24. Kusumoto FM, Schoenfeld MH, Barrett C, Edgerton JR, Ellenbogen KA, Gold MR, Goldschlager NF, Hamilton RM, Joglar JA, Kim RJ, Lee R, Marine JE, McLeod CJ, Oken KR, Patton KK, Pellegrini CN, Selzman KA, Thompson A, Varosy PD. 2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. Circulation. 2019 Aug 20;140(8):e382-e482.
25. Healey JS, Toff WD, Lamas GA, et al. Cardiovascular outcomes with atrial-based pacing compared with ventricular pacing: meta-analysis of randomized trials, using individual patient data. Circulation. 2006; 114:11–17.
26. Otto CM, Nishimura RA, Bonow RO, et al. 2020 ACC/AHA Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines [published correction appears in Circulation. 2021 Feb 2;143(5):e229]. Circulation. 2021;143(5):e72-e227. doi:10.1161/CIR.0000000000000923
27. Shen WK, Sheldon RS, Benditt DG, et al. 2017 ACC/AHA/HRS Guideline for the Evaluation and Management of Patients With Syncope: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the

Heart Rhythm Society [published correction appears in Circulation. 2017 Oct 17;136(16):e269-e270]. Circulation. 2017;136(5):e25-e59.
28. Liddy S, Buckley U, Kok HK, et al. Applications of cardiac computed tomography in electrophysiology intervention. Eur Heart J Cardiovasc Imaging. 2018;19(3):253-261. doi:10.1093/ehjci/jex312
29. Douglas PS, Hoffmann U, Patel MR, Mark DB, Al-Khalidi HR, Cavanaugh B, Cole J, Dolor RJ, Fordyce CB, Huang M, Khan MA, Kosinski AS, Krucoff MW, Malhotra V, Picard MH, Udelson JE, Velazquez EJ, Yow E, Cooper LS, Lee KL; PROMISE Investigators. Outcomes of anatomical versus functional testing for coronary artery disease. N Engl J Med. 2015 Apr 2;372(14):1291-300.
30. Hoffmann U, Ferencik M, Udelson JE, Picard MH, Truong QA, Patel MR, Huang M, Pencina M, Mark DB, Heitner JF, Fordyce CB, Pellikka PA, Tardif JC, Budoff M, Nahhas G, Chow B, Kosinski AS, Lee KL, Douglas PS; PROMISE Investigators. Prognostic Value of Noninvasive Cardiovascular Testing in Patients With Stable Chest Pain: Insights From the PROMISE Trial (Prospective Multicenter Imaging Study for Evaluation of Chest Pain). Circulation. 2017 Jun 13;135(24):2320-2332.
31. Abbara S, Blanke P, Maroules CD, et al. SCCT guidelines for the performance and acquisition of coronary computed tomographic angiography: A report of the society of Cardiovascular Computed Tomography Guidelines Committee: Endorsed by the North American Society for Cardiovascular Imaging (NASCI). J Cardiovasc Comput Tomogr. 2016;10(6):435-449. doi:10.1016/j.jcct.2016.10.002
32. ACR Committee on Drugs and Contrast Media. ACR Manual On Contrast Media - American College of Radiology. https://www.acr.org/-/media/ACR/files/clinical-resources/contrast_media.pdf. Accessed August 2022.
33. Lu MT, Ferencik M, Roberts RS, Lee KL, Ivanov A, Adami E, Mark DB, Jaffer FA, Leipsic JA, Douglas PS, Hoffmann U. Noninvasive FFR Derived From Coronary CT Angiography: Management and Outcomes in the PROMISE Trial. JACC Cardiovasc Imaging. 2017 Nov;10(11):1350-1358.
34. Edvardsen T, Asch FM, Davidson B, et al. Non-invasive imaging in coronary syndromes: recommendations of the European Association of Cardiovascular Imaging and the American Society of Echocardiography, in collaboration with the American Society of Nuclear Cardiology, Society of Cardiovascular Computed Tomography, and Society for Cardiovascular Magnetic Resonance. Eur Heart J Cardiovasc Imaging. 2022;23(2):e6-e33. doi:10.1093/ehjci/jeab244
35. Norgaard BL, et al. Coronary CT angiography-derived fractional flow reserve testing in patients with stable coronary artery disease: recommendations on interpretation and reporting. RSNA: Cardiothoracic Imaging. Nov 2019; 1(5): e190050.

36. US Food and Drug Administration. De Novo Classification Request For FFRCT V. 1.4. De Novo Summary (DEN130045). Published November 26, 2014. Accessed August 3, 2022.
37. Bokhari S, Lin JC, Julien HM. FDG-PET is a Superior Tool in the Diagnosis and Management of Cardiac Sarcoidosis. American College of Cardiology (ACC). 2017;.
38. Wolk MJ, Bailey SR, Doherty JU, et al. ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/SCCT/SCMR/STS 2013 multimodality appropriate use criteria for the detection and risk assessment of stable ischemic heart disease: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. J Am Coll Cardiol. 2014;63(4):380-406. doi:10.1016/j.jacc.2013.11.009
39. Expert Panel on Cardiac Imaging, Kicska GA, Hurwitz Koweek LM, et al. ACR Appropriateness Criteria® Suspected Acute Aortic Syndrome. J Am Coll Radiol. 2021;18(11S):S474-S481. doi:10.1016/j.jacr.2021.09.004
40. Expert Panel on Cardiac Imaging and Vascular Imaging:, Leipsic JA, Blanke P, et al. ACR Appropriateness Criteria® Imaging for Transcatheter Aortic Valve Replacement. J Am Coll Radiol. 2017;14(11S):S449-S455. doi:10.1016/j.jacr.2017.08.046
41. Dudley J. Pennell, Udo P. Sechtem, Charles B. Higgins, Warren J. Manning, Gerald M. Pohost, Frank E. Rademakers, Albert C. van Rossum, Leslee J. Shaw, E. Kent Yucel. Clinical indications for cardiovascular magnetic resonance (CMR): Consensus Panel report. European Heart Journal, Volume 25, Issue 21, November 2004, Pages 1940–1965, https://doi.org/10.1016/j.ehj.2004.06.040
42. Mathew RC, Löffler AI, Salerno M. Role of Cardiac Magnetic Resonance Imaging in Valvular Heart Disease: Diagnosis, Assessment, and Management. Curr Cardiol Rep. 2018;20(11):119. Published 2018 Sep 26. doi:10.1007/s11886-018-1057-9
43. Garner KK, Pomeroy W, Arnold JJ. Exercise Stress Testing: Indications and Common Questions. Am Fam Physician. 2017;96(5):293-299.
44. Darrow MD. Ordering and understanding the exercise stress test. Am Fam Physician. 1999;59(2):401-410.
45. Pellikka PA, Arruda-Olson A, Chaudhry FA, et al. Guidelines for Performance, Interpretation, and Application of Stress Echocardiography in Ischemic Heart Disease: From the American Society of Echocardiography. J Am Soc Echocardiogr. 2020;33(1):1-41.e8. doi:10.1016/j.echo.2019.07.001

46. Mulvagh SL, Rakowski H, Vannan MA, et al. American Society of Echocardiography Consensus Statement on the Clinical Applications of Ultrasonic Contrast Agents in Echocardiography. J Am Soc Echocardiogr. 2008;21(11):1179-1281. doi:10.1016/j.echo.2008.09.009
47. Hahn RT, Abraham T, Adams MS, et al. Guidelines for performing a comprehensive transesophageal echocardiographic examination: recommendations from the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. J Am Soc Echocardiogr. 2013;26(9):921-964. doi:10.1016/j.echo.2013.07.009
48. American College of Cardiology Foundation Appropriate Use Criteria Task Force; American Society of Echocardiography; American Heart Association; ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 Appropriate Use Criteria for Echocardiography. A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Society of Echocardiography, American Heart Association, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Critical Care Medicine, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance American College of Chest Physicians. J Am Soc Echocardiogr. 2011;24(3):229-267. doi:10.1016/j.echo.2010.12.008
49. Doherty JU, Kort S, Mehran R, Schoenhagen P, Soman P. ACC/AATS/AHA/ASE/ASNC/HRS/SCAI/SCCT/SCMR/STS 2017 Appropriate Use Criteria for Multimodality Imaging in Valvular Heart Disease. Journal of the American College of Cardiology. 2017;70(13):1647-1672. doi:10.1016/j.jacc.2017.07.732
50. ACC/AHA Guidelines for the Clinical Application of Echocardiography. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Clinical Application of Echocardiography). Developed in collaboration with the American Society of Echocardiography. Cheitlin MD, Alpert JS, Armstrong WF, Aurigemma GP, Beller GA, Bierman FZ, Davidson TW, Davis JL, Douglas PS, Gillam LD. Circulation. 1997;95(6):1686-1744. doi:10.1161/01.cir.95.6.1686
51. Thomas RJ, Beatty AL, Beckie TM, et al. Home-Based Cardiac Rehabilitation: A Scientific Statement From the American Association of Cardiovascular and Pulmonary Rehabilitation, the American Heart Association, and the American College of Cardiology. J Am Coll Cardiol. 2019;74(1):133-153. doi:10.1016/j.jacc.2019.03.008
52. Wenger NK. Current status of cardiac rehabilitation. J Am Coll Cardiol. 2008;51(17):1619-1631. doi:10.1016/j.jacc.2008.01.030
53. Taylor RS, Dalal HM, McDonagh STJ. The role of cardiac rehabilitation in improving cardiovascular outcomes [published online ahead of print, 2021 Sep 16]. Nat Rev Cardiol. 2021;1-15. doi:10.1038/s41569-021-00611-7

54. Mezzani A, Hamm LF, Jones AM, et al. Aerobic exercise intensity assessment and prescription in cardiac rehabilitation: a joint position statement of the European Association for Cardiovascular Prevention and Rehabilitation, the American Association of Cardiovascular and Pulmonary Rehabilitation and the Canadian Association of Cardiac Rehabilitation. Eur J Prev Cardiol. 2013;20(3):442-467. doi:10.1177/2047487312460484
55. Stout KK, et al. 2018 AHA/ACC guideline for the management of adults with congenital heart disease: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. Circulation 2019;139(14):e698-e800. DOI: 10.1161/CIR.0000000000000603.
56. Balady GJ, Ades PA, Bittner VA,Franklin BA, Gordon NF, et al. American Heart Association Science Advisory and Coordinating Committee. Referral, enrollment, and delivery of cardiac rehabilitation/secondary prevention programs at clinical centers and beyond: a presidential advisory from the American Heart Association. Circulation. 2011 Dec 20;124(25):2951-60
57. Priori SG, Blomström-Lundqvist C, Mazzanti A, et al. 2015 ESC Guidelines for the Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death. Rev Esp Cardiol (Engl Ed). 2016;69(2):176. doi:10.1016/j.rec.2016.01.001
58. 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. Heart Rhythm. 2014;11(7):1271-1303. doi:10.1016/j.hrthm.2014.03.041
59. Cronin EM, Bogun FM, Maury P, Peichl P, Chen M, Namboodiri N, Aguinaga L, Leite LR, Al-Khatib SM, Anter E, Berruezo A, Callans DJ, Chung MK, Cuculich P, d'Avila A, Deal BJ, Bella PD, Deneke T, Dickfeld TM, Hadid C, Haqqani HM, Kay GN, Latchamsetty R, Marchlinski F, Miller JM, Nogami A, Patel AR, Pathak RK, Saenz Morales LC, Santangeli P, Sapp JL Jr, Sarkozy A, Soejima K, Stevenson WG, Tedrow UB, Tzou WS, Varma N, Zeppenfeld K. 2019 HRS/EHRA/APHRS/LAHRS expert consensus statement on catheter ablation of ventricular arrhythmias: Executive summary. J Arrhythm. 2020 Jan 3;36(1):1-58. doi: 10.1002/joa3.12264.
60. van Zyl M, Kapa S, Padmanabhan D, et al. Mechanism and outcomes of catheter ablation for ventricular tachycardia in adults with repaired congenital heart disease. Heart Rhythm. 2016;13:1449–54.
61. Patel MR, Bailey SR, Bonow RO, et al. ACCF/SCAI/AATS/AHA/ASE/ASNC/HFSA/HRS/SCCM/SCCT/SCMR/STS 2012 appropriate use criteria for diagnostic catheterization: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, Society for Cardiovascular Angiography and Interventions, American Association for Thoracic Surgery, American

Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society of Critical Care Medicine, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. J Am Coll Cardiol. 2012;59(22):1995-2027. doi:10.1016/j.jacc.2012.03.003
62. Maragna R, Trombara F, Frappampina A, Dello Russo A, Gasperetti A, et al. Endomyocardial biopsy: what future in arrhythmogenic right ventricular dysplasia diagnosis?, European Heart Journal, Volume 41, Issue Supplement_2, November 2020, ehaa946.0748.
63. Lawton JS, Tamis-Holland JE, Bangalore S, et al. 2021 ACC/AHA/SCAI Guideline for Coronary Artery Revascularization: Executive Summary: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines [published correction appears in Circulation. 2022 Mar 15;145(11):e771]. Circulation. 2022;145(3):e4-e17. doi:10.1161/CIR.0000000000001039
64. O'Gara PT, Kushner FG, Ascheim DD, Casey DE Jr, Chung MK, de Lemos JA, Ettinger SM, Fang JC, Fesmire FM, Franklin BA, Granger CB, Krumholz HM, Linderbaum JA, Morrow DA, Newby LK, Ornato JP, Ou N, Radford MJ, Tamis-Holland JE, Tommaso CL, Tracy CM, Woo YJ, Zhao DX. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 2013;61:e78–140, doi:10.1016/j.jacc.2012.11.019.
65. Jones RH, Velazquez EJ, Michler RE, et al. Coronary bypass surgery with or without surgical ventricular reconstruction. N Engl J Med 2009; 360:1705–17.
66. Yancy CW, Jessup M, Bozkurt B, Butler J, Casey DE Jr, Drazner MH, Fonarow GC, Geraci SA, Horwich T, Januzzi JL, Johnson MR, Kasper EK, Levy WC, Masoudi FA, McBride PE, McMurray JJV, Mitchell JE, Peterson PN, Riegel B, Sam F, Stevenson LW, Tang WHW, Tsai EJ, Wilkoff BL. 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. J Am Coll Cardiol 2013;62:e147–239, https://doi.org/10.1016/j.jacc.2013.05.019.
67. Centers for Medicare and Medicaid Services. National Coverage Determination. Partial Ventriculectomy (20.26) Version 1. https://www.cms.gov/medicare-coverage-database/details/ncd-details.aspx?NCDId=122&ncdver=1&.
68. Duncker D, Veltmann C. The Wearable Cardioverter/Defibrillator - Toy Or Tool?. J Atr Fibrillation. 2016;8(6):1367. Published 2016 Apr 30. doi:10.4022/jafib.1367
69. Piccini JP Sr, Allen LA, Kudenchuk PJ, et al. Wearable Cardioverter-Defibrillator Therapy for the Prevention of Sudden Cardiac

Death: A Science Advisory From the American Heart Association. Circulation 2016
70. Kirklin JK, et al. American Association for Thoracic Surgery/International Society for Heart and Lung Transplantation guidelines on selected topics in mechanical circulatory support. Journal of Thoracic and Cardiovascular Surgery 2020;159(3):865-896. DOI: 10.1016/j.jtcvs.2019.12.021.
71. Rihal CS, Naidu SS, Givertz MM, et al. 2015 SCAI/ACC/HFSA/STS Clinical Expert Consensus Statement on the Use of Percutaneous Mechanical Circulatory Support Devices in Cardiovascular Care: Endorsed by the American Heart Association, the Cardiological Society of India, and Sociedad Latino Americana de Cardiologia Intervencion; Affirmation of Value by the Canadian Association of Interventional Cardiology-Association Canadienne de Cardiologie d'intervention. J Am Coll Cardiol. 2015;65(19):e7-e26. doi:10.1016/j.jacc.2015.03.036
72. Ravichandran PS. Mechanical Circulatory Support in a Nutshell. Expert Analysis, American College of Cardiology, November 13, 2015.
73. McDonagh TA, Metra M, Adamo M, et al. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. Eur Heart J. 2021;42(36):3599-3726. doi:10.1093/eurheartj/ehab368
74. Peura JL, Colvin-Adams M, Francis GS, et al. Recommendations for the use of mechanical circulatory support: device strategies and patient selection: a scientific statement from the American Heart Association. Circulation. 2012;126(22):2648-2667. doi:10.1161/CIR.0b013e3182769a54

Clinical Guideline Revision History/Information

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Review History	
February 17, 2022 (V.1)	**Physician author:** Alisa Niksch, MD (Pediatric Cardiologist/ Electrophysiologist), Mary Krebs, MD (Primary Care Physician) **Peer reviewed by:** Russell Rotondo, MD FACC (Cardiologist) **Approving Physician:** Russell Rotondo, MD FACC (Cardiologist)
October 31, 2022 (V.2)	**Peer reviewed by:** Ania Garlitski, MD (Cardiologist) **Approving Physician:** Russell Rotondo, MD FACC (Cardiologist)