



Medical Coverage Policy

Effective Date11/15/2025

Next Review Date11/15/2026

Coverage Policy Number..... 0011

Transcatheter Closure of Cardiovascular Defects

Table of Contents

Overview	2
Coverage Policy	2
Coding Information	3
General Background	3
Health Equity Considerations.....	21
Medicare Coverage Determinations	22
Levels of Scientific Evidence*	22
References.....	22
Revision Details.....	30

Related Coverage Resources

[Cardiac Omnibus Codes](#)
[Cardiac Rehabilitation \(Phase II Outpatient\)](#)
[Transcatheter Heart Valve Procedures](#)
[Transthoracic Echocardiography in Adults](#)
[Transthoracic Echocardiography in Children](#)
[Ventricular Assist Devices \(VADs\),](#)
[Percutaneous Cardiac Support Systems and](#)
[Total Artificial Heart](#)

INSTRUCTIONS FOR USE

The following Coverage Policy applies to health benefit plans administered by Cigna Companies. Certain Cigna Companies and/or lines of business only provide utilization review services to clients and do not make coverage determinations. References to standard benefit plan language and coverage determinations do not apply to those clients. Coverage Policies are intended to provide guidance in interpreting certain standard benefit plans administered by Cigna Companies. Please note, the terms of a customer's particular benefit plan document [Group Service Agreement, Evidence of Coverage, Certificate of Coverage, Summary Plan Description (SPD) or similar plan document] may differ significantly from the standard benefit plans upon which these Coverage Policies are based. For example, a customer's benefit plan document may contain a specific exclusion related to a topic addressed in a Coverage Policy. In the event of a conflict, a customer's benefit plan document always supersedes the information in the Coverage Policies. In the absence of a controlling federal or state coverage mandate, benefits are ultimately determined by the terms of the applicable benefit plan document. Coverage determinations in each specific instance require consideration of 1) the terms of the applicable benefit plan document in effect on the date of service; 2) any applicable laws/regulations; 3) any relevant collateral source materials including Coverage Policies and; 4) the specific facts of the particular situation. Each coverage request should be reviewed on its own merits. Medical directors are expected to exercise clinical judgment where appropriate and have discretion in making individual coverage determinations. Where coverage for care or services does not depend on specific circumstances, reimbursement will only be provided if a requested service(s) is submitted in accordance with the relevant criteria outlined in the applicable Coverage Policy, including covered diagnosis and/or procedure code(s). Reimbursement is not allowed for services when billed for conditions or diagnoses that are not

covered under this Coverage Policy (see "Coding Information" below). When billing, providers must use the most appropriate codes as of the effective date of the submission. Claims submitted for services that are not accompanied by covered code(s) under the applicable Coverage Policy will be denied as not covered. Coverage Policies relate exclusively to the administration of health benefit plans. Coverage Policies are not recommendations for treatment and should never be used as treatment guidelines. In certain markets, delegated vendor guidelines may be used to support medical necessity and other coverage determinations.

Overview

This coverage policy addresses the transcatheter approach for closure of secundum atrial septal defect (ASD), patent ductus arteriosus (PDA), fenestration following a Fontan procedure, muscular or perimembranous ventricular septal defect (VSD), known patent foramen ovale, ostium primum or sinus venosus atrial septal defect, and periventricular (transmyocardial) closure of VSDs using cardiac occlusion devices in neonates, infants, children, and adults.

Coverage Policy

Transcatheter closure with a U.S. Food and Drug Administration (FDA)-approved device used according to FDA labeling is considered medically necessary for ANY of the following conditions:

- secundum atrial septal defect (ASD)
- patent ductus arteriosus (PDA)
- fenestration following a Fontan procedure
- muscular or perimembranous ventricular septal defect (VSD) when ALL of the following criteria are met:
 - The VSD is of significant size to warrant closure.
 - The individual is considered to be at high risk for standard transatrial or transarterial surgical closure.
 - The individual is $\geq 5.2\text{kg}$
- closure of a known patent foramen ovale (PFO) when BOTH of the following criteria are met:
 - History of ischemic stroke presumed to be secondary to a paradoxical embolism following a negative workup for other causes of ischemic stroke.
 - Age 18 to 60 years

Transcatheter closure of a cardiovascular defect for any other indication (e.g., migraine, decompression illness prevention) is considered not medically necessary.

Transcatheter closure of ostium primum or sinus venosus atrial septal defects (ASDs) is considered not medically necessary.

Periventricular (transmyocardial) closure of ventricular septal defects (VSDs) is considered experimental, investigational, or unproven.

The use of ANY device not approved by the U.S. Food and Drug Administration (FDA) for the specific indication of cardiovascular defect closure (e.g., covered peripheral vascular stent for closure of an ostium primum or sinus venosus ASD) is considered not medically necessary.

Coding Information

Notes:

1. This list of codes may not be all-inclusive since the American Medical Association (AMA) and Centers for Medicare and Medicaid Services (CMS) code updates may occur more frequently than policy updates.
2. Deleted codes and codes which are not effective at the time the service is rendered may not be eligible for reimbursement.

Considered Medically Necessary when criteria in the applicable policy statements listed above are met:

CPT®* Codes	Description
93580 [†]	Percutaneous transcatheter closure of congenital interatrial communication (i.e., Fontan fenestration, atrial septal defect) with implant
93581	Percutaneous transcatheter closure of a congenital ventricular septal defect with implant
93582	Percutaneous transcatheter closure of patent ductus arteriosus

[†]Note: Considered Not Medically Necessary when used to report transcatheter closure of ostium primum or sinus venosus atrial septal defects

Considered Experimental/Investigational/Unproven when used to report perventricular (transmyocardial) closure of ventricular septal defects (VSDs):

CPT®* Codes	Description
33999	Unlisted procedure, cardiac surgery
93799	Unlisted cardiovascular service or procedure

***Current Procedural Terminology (CPT®) ©2024 American Medical Association: Chicago, IL.**

General Background

Medically Necessary

Atrial Septal Defect (ASD): ASDs represent a communication between the left and right atria and account for 7–10% of all congenital heart defects. ASDs may be located at different sites in the septum and range in size from small to large. The three major types of ASD (ostium secundum, ostium primum and sinus venosus) are named for their position in the atrial septum. Ostium secundum ASDs constitute 75–80% of all atrial septal defects and are located in the central portion of the septum (i.e., fossa ovalis). Ostium primum ASDs account for 15% of all ASDs and are located in the lower portion of the septum just above the atrioventricular valves. Sinus venosus or venous ASDs, which constitute 10% of all ASDs, occur at the junction of the superior vena cava and the right atrium. Moderate or large ASDs may be associated with significant left-to-right shunting, increase in pulmonary blood flow, and right ventricular volume overload. Risk factors associated with increased mortality from untreated ASD include the development of pulmonary vascular obstructive disease (i.e., pulmonary arteries thicken from prolonged left-to-right shunting), right atrial or ventricular enlargement, tricuspid regurgitation, pulmonary hypertension, cardiac rhythm disturbances, and stroke. Transcatheter closure using

implantable occlusive devices has evolved as an alternative to open surgical intervention in selected patients with secundum septal defects and has been shown to be safe and effective. Transcatheter closure is not an option for ostium primum and sinus venosus ASDs. These defects are located at the very lower and upper edges of the atrial septum, respectively, and are often associated with other valve abnormalities.

Although the indications for the procedure are the same as for surgical closure, the selection criteria are stricter in terms of defect size and surrounding rim tissue. Depending on the device, transcatheter closure can be performed only for patients with a secundum ASD with a stretched diameter of less than 41 mm and with adequate rims to enable secure device deployment. This technique is generally precluded in patients with anomalous pulmonary venous connection or with proximity of the defect to the AV valves, coronary sinus or systemic venous drainage. Major complications occur in less than 1% of patients, and clinical closure is achieved in more than 80% of patients. Device closure of an ASD improves functional status in symptomatic patients and exercise capacity in asymptomatic and symptomatic patients. Based on intermediate follow-up data, ASD device closure is safe and effective, with better preservation of right ventricular function and lower complication rates than with surgery (Webb, et al., 2019; 2015).

U.S. Food and Drug Administration (FDA):

Transcatheter septal occlusion devices are classified by the FDA as Class III medical devices and require premarket approval (PMA). The following devices are indicated for the closure of atrial septal defects (ASDs) in the ostium secundum position (FDA, 2025).

Device or Product	Identifier	Manufacturer	Decision Date
Amplatzer® Septal Occluder	P000039	Abbott	12/5/2001
GORE® CARDIOFORM Septal Occluder	P050006	W.L. Gore & Associates, Inc.	8/11/2006
Occlutech® ASD Occluder	P200032	Occlutech Holding AG	12/23/2023

*FDA product codes: MLV, OZG

Note: Device or product names are provided for example purposes only. Their inclusion does not indicate endorsement or preference for any specific brand or model. Coverage decisions are not based solely on FDA approval. This list is not intended to reflect all available products or technologies.

Literature Review : Transcatheter closure of secundum ASDs has been evaluated in case series reports and cohort reviews (Baroutidou, et al., 2023; Ghaderian, et al., 2021; Alnasser, et al., 2018; de Hemptinne, et al., 2017; Turner, et al., 2017; Smith, et al., 2014; Fischer, et al., 2003; Chessa, et al., 2002; Du, et al., 2002; Berger, et al., 1999). The consensus in these studies was that transcatheter closure is safe and effective in the majority of cases. Complications and complete closure rates were comparable to those seen with surgical closure and transcatheter closure offered the advantages of less morbidity and shorter hospitalizations.

Professional Societies/Organizations: The 2018 American College of Cardiology (ACC)/American Heart Association (AHA) Guidelines for the Management of Adults with Congenital Heart Disease (Stout, et al., 2019) include the following evidence-based therapeutic recommendations for closure of atrial septal defects:

Guideline Class of Recommendation (COR) and Level of Evidence (LOE) are described as follows:

Class (Strength) of Recommendation:

Class I (Strong) Benefit >>>Risk

Class IIa (Moderate) Benefit >> Risk
Class IIb (Weak) Benefit ≥ Risk
Class III No Benefit (Moderate) Benefit = Risk
Class III Harm (Strong) Risk > Benefit

Level (Quality) of Evidence:

Level A if the data were derived from high-quality evidence from more than one randomized clinical trial (RCT), meta-analyses of high-quality RCTs, or one or more RCTs corroborated by high-quality registry.

Level B-R when data were derived from moderate quality evidence from one or more RCTs, or meta-analyses of moderate-quality RCTs.

Level B-NR was used to denote moderate-quality evidence from one or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies. This designation was also used to denote moderate-quality evidence from meta-analyses of such studies.

Level C-LD when the primary source of the recommendation was randomized or nonrandomized observational or registry studies with limitations of design or execution, meta-analyses of such studies, or physiological or mechanistic studies of human subjects.

Level C-EO was defined as expert opinion based on the clinical experience of the writing group.

COR I

- "In adults with isolated secundum ASD causing impaired functional capacity, right atrial and/or RV enlargement, and net left-to-right shunt sufficiently large to cause physiological sequelae (e.g., pulmonary–systemic blood flow ratio [Qp:Qs] ≥1.5:1) without cyanosis at rest or during exercise, transcatheter or surgical closure to reduce RV volume and improve exercise tolerance is recommended, provided that systolic PA pressure is less than 50% of systolic systemic pressure and pulmonary vascular resistance is less than one third of the systemic vascular resistance (LOE: B-NR^{SR}).
- Adults with primum ASD, sinus venosus defect or coronary sinus defect causing impaired functional capacity, right atrial and/or RV enlargement and net left-to-right shunt sufficiently large to cause physiological sequelae (e.g., Qp:Qs ≥1.5:1) without cyanosis at rest or during exercise, should be surgically repaired unless precluded by comorbidities, provided that systolic PA pressure is less than 50% of systemic pressure and pulmonary vascular resistance is less than one third of the systemic vascular resistance" (LOE: B-NR)."

COR IIa

- "In asymptomatic adults with isolated secundum ASD, right atrial and RV enlargement, and net left-to-right shunt sufficiently large to cause physiological sequelae (e.g., Qp:Qs 1.5:1 or greater), without cyanosis at rest or during exercise, transcatheter or surgical closure is reasonable to reduce RV volume and/or improve functional capacity, provided that systolic PA pressure is less than 50% of systemic pressure and pulmonary vascular resistance is less than one third systemic resistance (LOE: C-LD^{SR}).
- Surgical closure of a secundum ASD in adults is reasonable when a concomitant surgical procedure is being performed and there is a net left-to-right shunt sufficiently large to cause physiological sequelae (e.g., Qp:Qs 1.5:1 or greater) and right atrial and RV enlargement without cyanosis at rest or during exercise (LOE: C-LD).
- Percutaneous or surgical closure may be considered for adults with ASD when net left-to-right shunt (Qp:Qs) is 1.5:1 or greater, PA systolic pressure is 50% or more of systemic arterial systolic pressure, and/or pulmonary vascular resistance is greater than one third of the systemic resistance (LOE: B-NR)."

COR III: Harm

- "ASD closure should not be performed in adults with PA systolic pressure greater than two thirds systemic, pulmonary vascular resistance greater than two thirds systemic, and/or a net right-to-left shunt (LOE: C-D)."

The recommendations developed by the writing committee on the basis of the systematic review are marked with "SR".

Patent Ductus Arteriosus (PDA): The ductus arteriosus is the vessel leading from the bifurcation of the pulmonary artery to the aorta, just distal to the left subclavian artery. Under normal circumstances, this channel is open in the fetus and closes spontaneously during the first few days of life. PDA results from the failure of this duct to close following birth. It is a common finding in premature infants and progressively decreases in frequency with increasing gestational age. In premature infants with compromised respiratory status, closure may be attempted using fluid restriction, diuresis, maintenance of good oxygenation, and medications such as indomethacin or by surgical ligation. Treatment of PDA in a preterm infant varies and depends on the degree of shunting and the severity of hyaline membrane disease. There is general agreement that closure of a hemodynamically significant PDA is indicated in children and adults. The safety and efficacy of transcatheter closure of PDA is established, with achievement of complete ductal closure in more than 85% of patients by one year, with a mortality rate of less than 1%. Surgical closure is generally reserved for patients in whom the defect is too large for device closure, or in centers without access to device closure. Surgical closure has a marginally greater closure rate than device closure, but is associated with slightly higher morbidity and mortality (Webb, et al., 2019; 2015).

U.S. Food and Drug Administration (FDA):

Transcatheter septal occlusion devices are classified by the FDA as Class III medical devices and require premarket approval (PMA). The following devices are indicated for percutaneous, catheter-based closure of a patent ductus arteriosus in patients who meet specific anatomical and clinical criteria. Collectively, they cover a wide range of patient populations, including premature infants and neonates, infants and children, and adults and adolescents (FDA, 2025).

Device or Product	Identifier	Manufacturer	Decision Date
Amplatzer™ Duct Occluder	P020024	Abbott	5/14/2003
Nit-Occlud® PDA	P120009	Pfm medical ag	8/16/2013
Amplatzer Piccolo™ Occluder	P020024/S052	Abbott	1/11/2019

*FDA product codes: MAE

Note: Device or product names are provided for example purposes only. Their inclusion does not indicate endorsement or preference for any specific brand or model. Coverage decisions are not based solely on FDA approval. This list is not intended to reflect all available products or technologies.

Literature Review: The safety and efficacy of transcatheter device closure for patent ductus arteriosus smaller than 8 mm has been established over the past 20 years, with complete ductal closure achieved in more than 85% of patients by one year with a mortality rate of less than 1%. Transcatheter closure has become the method of choice in centers with appropriate resources and experience. Although surgical closure has a marginally greater closure rate than device closure, the surgical mortality in adults is 1–3.5%, due to the presence of pulmonary arterial hypertension and difficult ductal morphology (e.g., calcified or aneurismal) frequently seen in adults. Surgical closure is therefore generally reserved for patients in whom the PDA is too large for device closure

or centers without access to device closure (Bischoff, et al., 2021; Sathanandam, et al., 2020; Webb, et al., 2019; 2015a; Gruenstein, et al., 2017; Butera, et al., 2004; Pass, et al., 2004).

In a 2023 evidence analysis of the Amplatzer Piccolo Occluder (Abbott) for Treating Patent Ductus Arteriosus, ECRI concluded that the, "Amplatzer Piccolo Occluder appears to work as well as or better than surgical ligation or other devices and offers the advantages of a transcatheter procedure for treating hemodynamically significant PDA in premature infants. One prospective and 10 retrospective comparison studies report similar mortality rates for ADO II AS and surgical ligation and similar PDA closure rates and device- or procedure-related complications for ADO II AS and other occlusion devices" (ECRI, 2023).

Bischoff, et al. (2021) conducted a systematic review and meta-analysis of observational case series to assess the safety and efficacy of percutaneous patent ductus arteriosus (PDA) closure with either a coil or device in infants ≤ 1.5 kg with subgroup analysis of infants ≤ 6.0 kg. There were 28 studies comprising 373 infants in the ≤ 1.5 kg group and 69 studies comprising 1,794 infants in the ≤ 6 kg subgroup. Studies evaluating infants weighing ≤ 6 kg at the time of PDA closure and studies including a comparator were included. Case reports or case series with < 3 participants, studies without data on the patient's weight or adverse events, and studies with mixed populations were excluded. The comparators included no treatment, medical therapy, and surgical closure. The primary outcome measured was technical success while adverse events served as the secondary outcome measured. Technical success was defined as successful placement of the device or coil in the PDA at the time the patient left the procedure room or cases of device or coil embolization that were retrieved and replaced with a different size device or coil during the same procedure. In the ≤ 1.5 kg group, technical success was achieved in 96% of percutaneous procedures, adverse events occurred in 27% of cases, and age at the time of the procedure was identified as a significant predictor for technical success ($p=0.004$). The incidence of major adverse events was 8% ($p=0.63$) and minor adverse events was 18% ($p<0.001$). Ten cases (2.7%) were considered technical failures including: cardiac perforation or hemopericardium resulting in death ($n=3$), conversion to surgical ligation ($n=3$), procedure abortion due to inferior vena cava dissection at the time of sheath advancement ($n=1$), cardiac tamponade converted to surgical ligation ($n=1$), iatrogenic aorta coarctation requiring surgical removal of the device and surgical ligation ($n=1$), and embolization to the left pulmonary artery that required surgical removal of the device and surgical ligation of the PDA ($n=1$). In a comparison between infants ≤ 1.5 kg and infants between 1.5-6.0 kg, the authors found that technical success and incidence of adverse events were higher in patients weighing 1.5-6.0 kg. Author noted limitations of the study included the absence of randomized controlled trials, heterogeneity of the indication for PDA closure, and heterogeneity of practice parameters. Additional limitations of the study include the small patient populations and short-term follow-up. The authors concluded that percutaneous PDA closure is successful and associated with a limited number of adverse events.

Professional Societies/Organizations: The 2018 ACC/AHA Guidelines for the Management of Adults with Congenital Heart Disease (Stout, et al., 2019) include the following evidence-based therapeutic recommendations for patent ductus arteriosus (PDA) closure:

Guideline Class of Recommendation (COR) and Level of Evidence (LOE) are described as follows:

Class (Strength) of Recommendation:

- Class I (Strong) Benefit $\gg \gg$ Risk
- Class IIa (Moderate) Benefit $\gg$ Risk
- Class IIb (Weak) Benefit $\geq$ Risk
- Class III No Benefit (Moderate) Benefit = Risk
- Class III Harm (Strong) Risk $>$ Benefit

Level (Quality) of Evidence:

Level A if the data were derived from high-quality evidence from more than one randomized clinical trial(RCT), meta-analyses of high-quality RCTs, or one or more RCTs corroborated by high-quality registry.

Level B-R when data were derived from moderate quality evidence from one or more RCTs, or meta-analyses of moderate-quality RCTs.

Level B-NR was used to denote moderate-quality evidence from one or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies. This designation was also used to denote moderate-quality evidence from meta-analyses of such studies.

Level C-LD when the primary source of the recommendation was randomized or nonrandomized observational or registry studies with limitations of design or execution, meta-analyses of such studies, or physiological or mechanistic studies of human subjects.

Level C-EO was defined as expert opinion based on the clinical experience of the writing group.

COR I

- PDA closure in adults if left atrial or left ventricular (LV) enlargement is present and attributable to PDA with net left-to-right shunt, PA systolic pressure less than 50% systemic and pulmonary vascular resistance less than one third systemic (LOE: C-LD).

COR IIb

- PDA closure in adults may be considered in the presence of a net left-to-right shunt if PA systolic pressure is 50% or greater systemic, and/or pulmonary vascular resistance is greater than one third systemic (LOE: B-NR).

COR III: Harm

- PDA closure should not be performed in adults with a net right-to-left shunt and PA systolic pressure greater than two thirds systemic or pulmonary vascular resistance greater than two thirds systemic (LOE: C-LD).

Fenestration Following Fontan Procedure: The Fontan procedure is a palliation procedure that involves separating the pulmonary and systemic blood flows in patients with single ventricular defects. The technique reduces the mixing of unoxygenated and oxygenated blood by directing blood flow from the right atrium to the pulmonary artery, excluding the ventricle from right-sided circulation. The procedure is intended to produce a normal workload on the ventricle. One component of this procedure involves leaving a hole or fenestration in the septum of the repaired section of the heart, allowing for some mixing of blood for patients who are unable to tolerate the change in venous pressure. The size of the fenestration varies, and smaller holes can close spontaneously. Some patients require the creation of larger holes and, in many of these patients, the fenestration will remain patent. In patients with cyanosis in the setting of a fenestrated Fontan, surgical or preferably transcatheter closure of the fenestration can be attempted. Postoperative closure of Fontan fenestrations using a test occlusion and subsequent permanent closure with an intracardiac device evolved based on growing experience with transcatheter techniques to close various intracardiac defects. Early and late closure after test occlusion has been reported to reduce mortality and morbidity after the Fontan procedure, especially in high-risk patients.

U.S. Food and Drug Administration (FDA):

Transcatheter septal occlusion devices are classified by the FDA as Class III medical devices and require premarket approval (PMA). The following device is indicated for closure of fenestrations in patients who have undergone a fenestrated Fontan procedure and now require occlusion of the fenestration (FDA, 2025).

Device or Product	Identifier	Manufacturer	Decision Date
Amplatzer® Septal Occluder	P000039	Abbott	12/5/2001

*FDA product codes: MLV

Note: Device or product names are provided for example purposes only. Their inclusion does not indicate endorsement or preference for any specific brand or model. Coverage decisions are not based solely on FDA approval. This list is not intended to reflect all available products or technologies.

Literature Review: Because of the relative rarity of this condition, published studies evaluating transcatheter closure of fenestrations following Fontan procedure are limited. There is sufficient evidence, however, to indicate that transcatheter septal occlusion is safe and effective for closure of a fenestration following a Fontan procedure in patients with single ventricle physiology.

Goff et al. (2000) published a multicenter registry study of patients who underwent catheter closure of a fenestrated Fontan with either the Clamshell (n=91) or CardioSEAL (n=63) device. All 63 patients who had their fenestrations treated with the CardioSEAL device achieved successful implantation. Late closure of the fenestration (at greater than six months after surgery) was followed by improved oxygenation, reduced need for anticongestive medication, and improved somatic growth at follow-up.

Ventricular Septal Defect (VSD): Congenital VSD can occur in isolation and as one part of a combination of cardiac anomalies. The natural history of congenital VSD may include spontaneous closure, development of pulmonary vascular obstruction, right ventricle outflow tract obstruction, aortic regurgitation, infective endocarditis, cardiomegaly, congestive cardiac failure and death in infancy. Many infants experience growth failure. Management of VSD is largely dependent on the size and pathophysiology of the defect. Patients with large defects and pulmonary hypertension are those at greatest risk of developing pulmonary vascular obstruction as well as respiratory infections. Large defects require correction early in life when pulmonary vascular disease is still reversible. Medical treatment may include diuretics, digitalis, and treatment of respiratory infections, as well as increased caloric density of feedings. Acquired VSD can occur post-myocardial infarction (MI), as well as following multiple trauma. It has been estimated that there is an 80–90% mortality rate within the first two months of the occurrence of a post-MI VSD with medical treatment alone. Rupture of the intraventricular septum is an uncommon but often fatal complication of acute MI or traumatic injury. Surgical closure of congenital and acquired ventricular septal defects is a well-established procedure with low perioperative mortality, a high closure rate, and positive immediate and short-term outcomes in patients with suitable anatomy. Since long-term data are not yet available, transcatheter VSD closure should be reserved for patients with VSD of significant size to warrant closure who are at high risk for standard surgical closure.

U.S. Food and Drug Administration (FDA):

Transcatheter septal occlusion devices are classified by the FDA as Class III medical devices and require premarket approval (PMA). The following devices are indicated for the closure of complex or muscular ventricular septal defects of significant size to warrant closure in patients who are at high risk for surgical repair due to anatomical challenges, prior failed surgical closure, or medical comorbidities. These devices are contraindicated in individuals <5.2kg or in individuals whose vasculature isn't of sufficient size to accommodate the delivery sheath (FDA, 2025).

Device or Product	Identifier	Manufacturer	Decision Date
CardioSEAL® Septal Occlusion System with Qwik Load™	P000049	NMT Medical, Inc.	12/5/2001
Amplatzer™ Muscular VSD Occluder	P040040	Abbott	9/7/2007

*FDA product codes: MLV

Note: Device or product names are provided for example purposes only. Their inclusion does not indicate endorsement or preference for any specific brand or model. Coverage decisions are not based solely on FDA approval. This list is not intended to reflect all available products or technologies.

Literature Review: Transcatheter closure is an established treatment option for complex ventricular septal defect (VSD) repair. Although there is a limited number of studies investigating transcatheter closure for VSD repair, case series (n=30–848), retrospective reviews (n=104), and systematic review and meta-analysis of prospective and retrospective (randomized and non randomized) trials (n=6–462) reporting up to 7.5 years of data reported favorable success rates and long-term results. There is variability as to the type of device used for the closure (Cen, et al., 2021; Weryński, et al., 2021; Yang, et al., 2021; Yang, et al., 2010; Butera, et al., 2007; Masura, et al., 2005; Tanopoulos and Riby, 2005; Arora, et al., 2004).

Professional Societies/Organizations:

American Heart Association (AHA)/American College of Cardiology (ACC): The 2018 ACC/AHA Guidelines for the Management of Adults with Congenital Heart Disease (Stout, et al., 2019) include the following evidence-based therapeutic recommendations for closure of a ventricular septal defect (VSD). The authors added that transcatheter occlusion of muscular and perimembranous VSD has demonstrated good safety and efficacy profile.

Guideline Class of Recommendation (COR) and Level of Evidence (LOE) are described as follows:

Class (Strength) of Recommendation:

- Class I (Strong) Benefit >>>Risk
- Class IIa (Moderate) Benefit>>Risk
- Class IIb (Weak) Benefit ≥ Risk
- Class III No Benefit (Moderate) Benefit=Risk
- Class III Harm (Strong) Risk>Benefit

Level (Quality) of Evidence:

- Level A if the data were derived from high-quality evidence from more than one randomized clinical trial(RCT), meta-analyses of high-quality RCTs, or one or more RCTs corroborated by high-quality registry.
- Level B-R when data were derived from moderate quality evidence from one or more RCTs, or meta-analyses of moderate-quality RCTs.
- Level B-NR was used to denote moderate-quality evidence from one or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies. This designation was also used to denote moderate-quality evidence from meta-analyses of such studies.
- Level C-LD when the primary source of the recommendation was randomized or nonrandomized observational or registry studies with limitations of design or execution, meta-analyses of such studies, or physiological or mechanistic studies of human subjects.
- Level C-EO was defined as expert opinion based on the clinical experience of the writing group.

COR I

- Adults with a VSD and evidence of left ventricular volume overload and hemodynamically significant shunts ($Q_p:Q_s \geq 1.5:1$) should undergo VSD closure, if pulmonary artery (PA) systolic pressure is less than 50% systemic and pulmonary vascular resistance is less than one third systemic (LOE: B-NR).

COR IIa

- Surgical closure of perimembranous or supracristal VSD is reasonable in adults when there is worsening aortic regurgitation (AR) caused by VSD (LOE: C-LD).

COR IIb

- Surgical closure of a VSD may be reasonable in adults with a history of infective endocarditis (IE) caused by VSD if not otherwise contraindicated (Level of Evidence: C-LD).
- Closure of a VSD may be considered in the presence of a net left-to-right shunt ($Q_p:Q_s \geq 1.5:1$) when PA systolic pressure is 50% or more than systemic and/or pulmonary vascular resistance is greater than one third systemic (LOE: C-LD).

COR III: Harm

- VSD closure should not be performed in adults with severe pulmonary arterial hypertension (PAH) with PA systolic pressure greater than two thirds systemic, pulmonary vascular resistance greater than two thirds systemic and/or a net right-to-left shunt (LOE: C-LD).

American College of Cardiology (ACC): In a 2022 review (Turner, et al., 2022), the American College of Cardiology stated that limitations for percutaneous VSD closure still exist despite considerable growth in understanding, techniques, and device selection and that surgical closure remains the preferred treatment strategy. However, they point to several defects that can be considered for transcatheter closure including defects that are, “anatomically favorable for device implantation, with adequate space to avoid injury to surrounding structures such as the aortic and atrioventricular valves”. The ACC stated that, “transcatheter device closure of MVSDs is reasonable in patients who weigh ≥ 5 kg with hemodynamically significant defects and suitable anatomy (Class IIa, LOE B).

Patent Foramen Ovale (PFO): The foramen ovale, a remnant of the fetal circulation, is a tunnel-like space between the overlying septum secundum and septum primum. In fetal life, this interatrial communication directs blood flow from the umbilical vein to the left atrium. After birth, the left atrial pressure increases and the valve to the fossa ovalis closes. In approximately 25% of people, however, this fusion is not complete. This persistent communication is a variant of atrial septal defect (ASD), but differs from ASD in morphology and associated signs and symptoms. The flap-like opening seen with PFO however, is usually not clinically significant in healthy adults, and is generally not treated unless conditions such as pulmonary hypertension, chronic obstructive pulmonary disease or pulmonary embolism are present. These conditions may cause the right atrial pressure to be elevated, causing an increased potential for right-to-left shunting through the PFO. PFOs have been scrutinized for their implication in the mechanism of cryptogenic stroke (i.e. stroke with no other known cause of cerebral ischemia). Although basic principles linking PFO and stroke are plausible, this link has not been demonstrated. It has been proposed that PFOs may serve as a conduit for paradoxical embolization from the venous side to the systemic circulation, or as a point of origin for thrombus formation because of their tunnel-like structure and tendency for stagnant flow. A coordinated series of events is necessary for a paradoxical embolism through a PFO to occur, however. Therefore, even in patients with a history of cryptogenic stroke, the risk of recurrence may not be high (Webb, et al., 2019, 2015a; Almekhlafi et al., 2009).

Antiplatelet therapy may be indicated for patients with PFO who have had a cryptogenic stroke or transient ischemic attack (TIA). Warfarin may be recommended for patients with other indications for oral anticoagulation, including patients with an underlying hypercoagulation state, or those with evidence of venous thrombosis. There is no clear evidence to demonstrate whether warfarin or aspirin is superior in preventing recurrent stroke or death. It is also unclear whether patients treated medically following a cryptogenic stroke are at increased risk for a subsequent stroke or death because of the presence of PFO. Transcatheter closure has been proposed as an alternative to medical therapy in patients with PFO associated with cryptogenic stroke and has been shown to be safe and effective (Sacco, et al., 2006).

Several other clinical conditions have been attributed to the presence of a PFO. It has been proposed that PFO may be implicated in the pathophysiologic mechanism of migraine headaches, decompression sickness in deep sea divers (arterial gas embolism from the venous side), and platypnoea-orthodeoxia syndrome (dyspnea and arterial desaturation in the upright position, which improves on lying down). There is insufficient evidence to determine whether the presence of a PFO is involved in the pathophysiologic mechanisms of these conditions or to determine the safety and efficacy of transcatheter PFO closure for these indications. (Webb, et al., 2019, 2015; Mattle, et al., 2010).

Numerous trials addressing transcatheter closure of PFO are listed in the ClinicalTrials.gov database.

U.S. Food and Drug Administration (FDA):

Transcatheter septal occlusion devices are classified by the FDA as Class III medical devices and require premarket approval (PMA). The following devices are indicated for the closure of a patent foramen ovale (PFO) to reduce the risk of recurrent ischemic stroke in patients, predominantly between the ages of 18-60 years, who have had a cryptogenic stroke due to a presumed paradoxical embolism, as determined by a neurologist and cardiologist following an evaluation to exclude known causes of ischemic stroke (FDA, 2025).

Device or Product	Identifier	Manufacturer	Decision Date
Amplatzer PFO Occluder	P120021	Abbott	10/28/2016
GORE® CARDIOFORM Septal Occluder	P050006	W.L. Gore & Associates, Inc.	3/30/2018

*FDA product codes: MLV

Note: Device or product names are provided for example purposes only. Their inclusion does not indicate endorsement or preference for any specific brand or model. Coverage decisions are not based solely on FDA approval. This list is not intended to reflect all available products or technologies.

Literature Review: Transcatheter closure for a known patent foramen ovale (PFO) is an established treatment option for individuals who have a history of ischemic stroke presumed to be secondary to a paradoxical embolism. Case series and retrospective reviews reporting up to 5.9 years of data demonstrated outcomes comparable to medical therapy following transcatheter closure. Some outcomes suggested closure is associated with a lower risk of stroke recurrence or other cerebrovascular events. Complication rates are similar between closure and medical therapy with the exception of atrial fibrillation; which may occur more frequently in patients treated with PFO closure. Studies are limited by the heterogeneity of the types of devices used and the treatment parameters. (Kavinsky, et al., 2022; Vaduganathan, et al., 2018; Hayes, 2017, updated 2019; Kheiri, et al., 2019; Nasir, et al., 2019; Hayes, 2018, updated 2019; Lee, et al., 2018; Riaz, et al., 2018; Sa, et al., 2018; Mas, et al., 2017; Saver, et al., 2017; Søndergaard, et al., 2017;

FDA, 2016; Chen, et al., 2014; Carroll, et al., 2013; Meier, et al., 2013; Furlan, et al., 2012; Almedhlafi, et al., 2009; Harms, et al., 2007; Demkow, et al., 2004).

Not Medically Necessary

Migraine: Transcatheter closure of a known patent foramen ovale has also been proposed for the treatment of migraine. Migraine with aura has been associated with PFO and with other causes of right-to-left shunts. The evidence in the published peer-reviewed literature does not support the effectiveness of PFO closure for this indication. Available studies are limited by small patient populations, short-term follow-ups, incomplete data reporting and conflicting results (Wang, et al., 2022; Zhang, et al., 2022; Mojadidi, et al., 2021; Zhang, et al., 2021; Dowson, et al., 2008).

Mojadidi et al. (2021) conducted a pooled analysis of two randomized controlled trials (RCT) (i.e., Tobis, et al., 2017, Mattle, et al., 2016) to evaluate the safety and efficacy of percutaneous PFO closure in individuals with migraine compared with medical therapy alone. Participants in the Mattle, et al. (2016) study (n=107) were not blinded to treatment allocation. Participants in the Tobis, et al. (2017) study (n=230) were blinded initially, but were then un-blinded after one year. In both studies, participants were treated with 1–3 months of clopidogrel and six months of aspirin. Participant ages ranged from 18–65 years. The intervention consisted of percutaneous PFO closure using the Amplatzer PFO Occluder device combined with medical management. The comparator in Mattle, et al. (2016) was medical treatment alone and the comparator in Tobis, et al. (2017) was sham PFO closure (e.g., right heart catheterization) with medical treatment. The pooled analysis included the following primary endpoints: mean reduction in monthly migraine days, mean reduction in monthly migraine attacks, responder rate (i.e., $\geq 50\%$ reduction in migraine attacks), and complete migraine cessation. Subgroup analysis took place for those participants who experienced migraine with aura or frequent aura. Secondary outcomes included adverse events, vascular procedural complications, atrial fibrillation, or major bleeding episode. Significant improvement in monthly migraine days, migraine attacks, and complete migraine cessation at 12 months post-intervention was observed in the PFO closure group compared to the control group ($p=0.02$, $p=0.01$, $p<0.001$, respectively). Improvement in responder rate did not achieve statistical significance between the PFO closure group and control group ($p=.13$). Compared with the control group, subgroup analysis for those participants with aura or frequent aura demonstrated a significant reduction in migraine days ($p=0.03$) and complete headache cessation ($p=0.002$). However, statistical significance was not achieved for those without aura compared with the control for migraine days ($p=0.53$) or complete headache cessation ($p=0.16$). The responder rate was significantly greater in participants with frequent aura compared with control ($p=0.005$) but not in participants with infrequent aura ($p=0.69$). Adverse events included: access-site bleeding, hematoma, hypotension, tachycardia, vasovagal episode, fatigue, non-sustained atrial fibrillation, and syncope. Author noted limitations included: heterogeneity of treatment parameters and patient characteristics (e.g., history of head trauma, mood disorders, palpitations, steroid use) and the short-term follow-up. Additional limitations included participant attrition and the small patient population.

Dowson et al. (2008) conducted a prospective, double-blind, randomized controlled trial to evaluate the effectiveness of PFO closure in patients with migraine with aura who experienced frequent migraine attacks, had failed $\geq$ two classes of prophylactic treatments, and had moderate to large right-to-left shunts consistent with the presence of PFO. Patients were randomized to transcatheter closure with the STARFlex implant (NMT Medical, Inc., Boston MA) (n=74) or to a sham procedure (n=73). The primary efficacy endpoint was migraine headache cessation 91–180 days after the procedure. There was no significant difference in the primary outcome between the two groups; in the treatment group, 3 of 74 patients experienced headache cessation, compared to 3 of 73 patients in the sham group.

Schwedt et al. (2008) conducted a systematic review to evaluate the association of PFO and migraine and to assess the effect of PFO closure on migraine. Six retrospective studies met the inclusion criteria for the effect of PFO closure on migraine. The authors stated that the low-to-moderate grade of evidence from observational studies supports an apparent association between PFO and migraine, and that although PFO closure seemed to have a favorable effect on migraine patterns, the very low grade of available evidence to support this association precludes definitive conclusions.

Professional Societies/Organizations: In a 2022 guideline on the management of PFO, the Society for Cardiovascular Angiography and Interventions gave a conditional recommendation with a moderate certainty of evidence against PFO closure in persons experiencing migraines without a prior PFO-associated stroke. The recommendation is based on three randomized controlled trials (n=83–230) that failed to achieve their primary efficacy endpoints of eliminating or reducing migraine attacks per month (Kavinsky, et al., 2022; Tobis, et al., 2017; Mattle, et al., 2016; Dowson, et al., 2008).

Secondary Prevention of Recurrent Paradoxical Embolism in Deep Sea Divers: Patent foramen ovale (PFO) closure has been proposed as a means of secondary prevention of recurrent paradoxical embolism in deep sea divers. Inert gas accumulates within blood and tissues during a dive. Assuming appropriate decompression schedules are followed, on ascent that gas is excreted by the lungs. During a deep or long dive, venous gas emboli can form and in the presence of a PFO, these emboli can become arterialized resulting in symptoms of a stroke. This is referred to as neurological decompression illness (NICE, 2010). According to Anderson, et al. (2019), the risk of neurological decompression sickness in divers with a PFO is approximately 4-6 out of 10,000 dives or, in other words, 4-6 times that of a diver without a PFO. Conservative risk mitigation strategies include diving cessation and diving more conservatively to prevent the presence of post-dive venous gas bubbles.

Anderson et al. (2019) conducted a prospective, observational study of divers (n=65) to compare the effectiveness of patent foramen ovale (PFO) closure (n=42) and conservative diving (n=23) in decompression sickness (DCS) risk mitigation. The mean age of patients in the conservative group was 52 years and in the closure group was 45.5 years old. Adult participants were included in the study if they: were certified divers, had a diagnosis of PFO regardless of the DCS history, and planned to continue diving. After diagnosis with a PFO, divers who decided to continue diving without undergoing PFO closure were classified as “conservative”. Those who decided to undergo PFO closure were classified as “closure”. The primary outcome followed was “confirmed DCS” defined as cases diagnosed by a medical professional and requiring treatment in a recompression chamber. Secondary outcomes followed were cases of “possible DCS” which was defined as subjective reports of: vertigo, joint pain, skin itching and rash, post-dive skin mottling, breast swelling, muscular weakness, or use of in-water recompression or surface oxygen to alleviate symptoms. Additional secondary outcomes were: return to diving, frequency and intensity of diving after the intervention, and possible adverse events related to the closure. The median follow-up period was five years for the conservative group and six years for the closure group. The number of confirmed DCS cases in the conservative group decreased non-significantly from 12.8 to 6.2 while confirmed cases in the closure group decreased significantly from 13.1 to 2.7 ($p < 0.05$). The number of possible DCS cases in the conservative group increased significantly from 31.3 to 131.2 ($p < 0.0001$). The number of possible DCS cases in the closure group decreased significantly from 144.5 to 42.1 ($p < 0.0001$). The authors postulated that the increase in possible DCS in the conservative group may have been attributed to the fact that the divers may have become more vigilant of DCS symptoms after PFO diagnosis. On average, fewer dives were reported in both groups per year after intervention. Stratification by PFO size suggested that divers with large PFOs who underwent closure would reduce incidences of possible DCS while those with small PFOs would not. Of those who underwent closure, adverse events occurred in

19% of divers and included: post-surgical bleeding, transient atrial fibrillation, migraine with aura, dysrhythmia, heart palpitations, premature atrial and ventricular contractions, supraventricular tachycardia, and allergic reaction to a muscle relaxant used during surgery. Author reported limitations of the study included: small sample size, bias due to self-enrollment, subjective reports of DCS, heterogeneity of clinical practices, and a lack of available medical documentation. The authors concluded that PFO closure could benefit healthy deep sea divers with a significant DCS burden and large PFO who wish to pursue advanced diving. Additional high quality studies are needed to fully assess the value of PFO closure as a risk mitigation strategy for deep sea divers.

Pearman et al. (2015) conducted a retrospective review of one cardiologist's practice to assess the safety and efficacy of PFO closure for the prevention of decompression illness in divers (n=106). Patients ranged in age from 16–63 years. Patients were implanted with either the Amplatzer (n=89), Gore Septal Occluder (n=7), Premere (n=6), Helex (n=3), or Starflex (n=1). Data from the RESPECT study, which evaluated PFO closure for the indication of cryptogenic stroke, served as the benchmark for evaluation. Outcomes measured included: the efficacy of PFO closure, complications related to the procedure, and the likelihood of being able to return to diving. Eighty percent of patients were considered fit for unrestricted diving after closure as evidenced by the lack of a shunt or the presence of a mild shunt on bubble contrast echocardiography. At the time of writing the review, 81/98 divers were followed up on and cleared to resume unrestricted diving, three patients had residual shunts, and 14 were given restrictions on their diving depths. Complications were found to be similar to those observed in the RESPECT trial and included: atrial fibrillation, atrial flutter, stroke, transient inferior ST segment elevation, retroperitoneal hematoma, vagal symptoms, palpitations, chest pain, nausea, and dizziness. Limitations of the review include the retrospective design, small patient population, and use of a benchmark study that did not evaluate PFO closure for the prevention of decompression illness in divers. Additional, high quality studies are needed to assess the safety and efficacy of PFO closure for the prevention of decompression illness in deep sea divers.

Professional Societies/Organizations: In a 2022 guideline on the management of PFO, the Society for Cardiovascular Angiography and Interventions gave a conditional recommendation with a very low certainty of evidence against PFO closure to prevent decompression illness (DCI) in SCUBA divers with prior DCI and without a prior PFO-associated stroke. The recommendation is based on three observational studies (n=35–153) that showed PFO closure may reduce the incidence of recurrent DCI. However, the literature is limited by observational and non-randomized trials that are inconclusive and fail to define optimal risk stratification for management (Kavinsky, et al., 2022; Honěk, et al., 2020; Anderson, et al., 2019; Koopsen, et al., 2018).

After a review of the literature, the American Academy of Neurology (AAN) (Messe, et al., 2020) issued a practice advisory regarding patent foramen ovale (PFO) closure in individuals with cryptogenic stroke. They found that percutaneous PFO closure “probably reduces the risk of stroke recurrence”, has a periprocedural complication rate of 3.9%, and “probably is associated with the development of serious nonperiprocedural atrial fibrillation”. The AAN included the following recommendations in their advisory:

- “In patients being considered for PFO closure, clinicians should ensure that an appropriately thorough evaluation has been performed to rule out alternative mechanisms of stroke, as was performed in all positive PFO closure trials.
- In patients being considered for PFO closure, clinicians should obtain brain imaging to confirm stroke size and distribution, assessing for an embolic pattern or a lacunar infarct (typically involving a single deep perforator, <1.5 cm in diameter).
- In patients being considered for PFO closure, clinicians should obtain complete vascular imaging (MRA or CTA) of the cervical and intracranial vessels to look for dissection, vasculopathy, and atherosclerosis.

- In patients being considered for PFO closure, clinicians must perform a baseline ECG to look for atrial fibrillation.
- Select patients being considered for PFO closure thought to be at risk of atrial fibrillation should receive prolonged cardiac monitoring for at least 28 days.
- In patients being considered for PFO closure, clinicians should assess for cardioembolic sources using TTE followed by TEE assessment if the first study does not identify a high-risk stroke mechanism. Studies should use bubble contrast, with and without Valsalva maneuver, to assess for right-to-left shunt and determine degree of shunting.
- In patients being considered for PFO closure, clinicians should perform hypercoagulable studies that would be considered a plausible high-risk stroke mechanism that would lead to a change in management such as requiring lifelong anticoagulation (e.g., persistent moderate- or high-titer antiphospholipid antibodies in a younger patient with cryptogenic stroke).
- Before undergoing PFO closure, patients should be assessed by a clinician with expertise in stroke to ensure that the PFO is the most plausible mechanism of stroke.
- If a higher risk alternative mechanism of stroke is identified, clinicians should not routinely recommend PFO closure.
- In patients younger than 60 years with a PFO and an embolic appearing infarct and no other mechanism of stroke identified, clinicians may recommend closure following a discussion of potential benefits (reduction of stroke recurrence) and risks (procedural complication and atrial fibrillation)."

The American Heart Association (AHA)/American Stroke Association (ASA) Guidelines for the Prevention of Stroke in Patients with Stroke and Transient Ischemic Attack (Kleindorfer, et al., 2021) include the following recommendations for patent foramen ovale (PFO):

Classification (strength) of Recommendations:

- Class 1: Strong; Benefit >>>Risk
- Class 2a: Moderate; Benefit>>Risk
- Class 2b: Weak; Benefit ≥ Risk
- Class 3: No Benefit (Moderate); Benefit = Risk
- Class 3: Harm (Strong); Risk > Benefit

Levels of Evidence:

- Level A
 - High-quality evidence from more than 1 RCT
 - Meta-analysis of high-quality RCTs
 - One or more RCTs corroborated by high-quality registry studies
- Level B-R
 - Moderate-quality evidence from 1 or more RCTs
 - Meta-analyses of moderate-quality RCTs
- Level B-NR
 - Moderate-quality evidence from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies
 - Meta-analysis of such studies
- Level C-LD
 - Randomized or nonrandomized observational or registry studies with limitations of design or execution
 - Meta-analysis of such studies
 - Physiological or mechanistic studies in human subjects
- Level C-EO
 - Consensus of expert opinion based on clinical experience

Class 1

- "In patients with a nonlacunar ischemic stroke of undetermined cause and a PFO, recommendations for PFO closure versus medical management should be made jointly by the patient, a cardiologist, and a neurologist, taking into account the probability of a causal role for the PFO (Level C-EO).

Class 2a

- In patients 18 to 60 years of age with a nonlacunar ischemic stroke of undetermined cause despite a thorough evaluation and a PFO with high-risk anatomic features, it is reasonable to choose closure with a transcatheter device and long-term antiplatelet therapy over antiplatelet therapy alone for preventing recurrent stroke (Level B-R).

Class 2b

- In patients with ischemic stroke or TIA in whom patent foramen ovale (PFO) closure would be contemplated, TCD (transcranial Doppler) with embolus detection might be reasonable to screen for right-to-left shunt (Level C-LD).
- In patients 18 to 60 years of age with a nonlacunar ischemic stroke of undetermined cause despite a thorough evaluation and a PFO without high-risk anatomic features, the benefit of closure with a transcatheter device and long-term antiplatelet therapy over antiplatelet therapy alone for preventing recurrent stroke is not well established (Level C-LD).
- In patients 18 to 60 years of age with a nonlacunar ischemic stroke of undetermined cause despite a thorough evaluation and a PFO, the comparative benefit of closure with a transcatheter device versus warfarin is unknown (Level C-LD)."

The American College of Chest Physicians Evidence-Based Clinical Practice Guideline, Antithrombotic Therapy and Prevention of Thrombosis (Guyatt, et al., 2012) includes the following recommendations for patients with PFO and atrial septal aneurysms:

- In patients with cryptogenic stroke and PFO or atrial septal aneurysm, we recommend aspirin (50-100 mg) over no aspirin (Grade 1A, strong recommendation, high quality evidence)
- In patients with cryptogenic stroke and PFO or atrial septal aneurysm, who experience recurrent events despite aspirin therapy, we suggest treatment with vitamin K antagonist (VKA therapy), and consideration of device therapy over aspirin therapy (Grade 2C, weak recommendation, low or very low quality evidence)
- In patients with cryptogenic stroke and PFO, with evidence of deep vein thrombosis, we recommend VKA therapy for three months and consideration of device therapy over no VKA therapy or aspirin therapy (Grade 2C, weak recommendation, low-or very low quality evidence)

A science advisory on percutaneous device closure of patent foramen ovale for secondary stroke prevention was issued by the American Heart Association/American Stroke Association and the American College of Cardiology, and was affirmed by the American Academy of Neurology (O'Gara et al., 2009). According to the advisory, the optimal therapy for prevention of recurrent stroke or transient ischemic attack in patients with cryptogenic stroke and patent foramen ovale has not been defined. Although a strong association between patent foramen ovale and cryptogenic stroke has been suggested by numerous observational studies, a causal relationship has not been convincingly established for the majority of affected patients. The advisory further states:

"The choice between medical therapy and percutaneous device closure has been the subject of intense debate over the past several years, albeit one that has not been adequately informed by randomized, prospective clinical trial data to permit an objective comparison of the relative safety and efficacy of these respective approaches. Enrollment in clinical trials has lagged considerably despite frequent calls for participation from the US Food and Drug Administration and major professional

societies. Completion and peer review of ongoing trials are critical steps to establish an evidence base from which clinicians can make informed decisions regarding the best therapy for individual patients. The present advisory strongly encourages all clinicians involved in the care of appropriate patients with cryptogenic stroke and patent foramen ovale—cardiologists, neurologists, internists, radiologists, and surgeons—to consider referral for enrollment in these landmark trials to expedite their completion and help resolve the uncertainty regarding optimal care for this condition.”

Off-Label Devices:

Covered Peripheral Vascular Stents have been proposed for use in closing off ostium primum and sinus venosus atrial septal defects (ASDs). A covered stent is one that has been coated or lined with a synthetic material which is proposed to allow the stent to seal off abnormal openings or redirect blood flow. With a covered stent approach for the closure of a sinus venosus ASD, the stent is deployed in the SVC-right atrial junction which covers the ASD, preventing left-to-right shunting, redirects anomalous pulmonary veins to drain into the left atrium behind the stent, and preserves SVC flow into the right atrium through the lumen of the stent. With this procedure, the native tissue defect remains anatomically present, however it is sealed off by the stent covering.

U.S. Food and Drug Administration (FDA): The U.S. Food and Drug Administration (FDA) has not approved or cleared peripheral vascular stents for the closure of cardiovascular defects. These devices are regulated as Class III medical devices and are specifically indicated for use in peripheral arteries. Use of peripheral vascular stents outside their approved labeling—such as for intracardiac defect closure—is considered an off-label application for which the FDA has not established safety or effectiveness (FDA, 2010; FDA 2024; FDA 2024b).

Literature Review:

Ostium Primum ASD: A review of the literature reveals no published studies, case reports, or clinical trials supporting the use of covered stents for ostium primum ASD closure. The only documented cases of ostium primum ASD repair involve open-heart surgical techniques, often with concurrent mitral valve repair, due to the anatomical complexity and proximity to the atrioventricular valves. Use of covered stents for primum defects pose a high risk of valve interference due to the lack of structural margins necessary for secure device anchoring.

Sinus Venosus ASD: The current peer-reviewed literature evaluating the safety and efficacy of covered stent implantation for the treatment of sinus venosus atrial septal defects (SVASD) is limited to retrospective, observational studies with significant methodological constraints. These studies lack randomized comparator arms, standardized inclusion criteria, procedural protocols, and fail to compare the intervention to the standard of care (surgical repair). Variability in stent types, implantation techniques, imaging modalities, and follow-up durations further limits generalizability (Rosenthal, et al., 2025; Brancato, et al., 2023; Rosenthal, et al., 2021; Hansen, et al., 2020).

Rosenthal et al. (2025) conducted a retrospective observational registry study to evaluate the uptake of a covered stent correction (CSC) procedure for sinus venosus atrial septal defects (SVASD). There were 381 procedures reported across 54 international centers. The median patient age was 44 years (range: 4.75–87), with a nearly equal gender distribution (49.4% male, 50.6% female). The authors reported a high technical success rate of 97.4% and avoidance of cardiopulmonary bypass in most cases. However, the study revealed substantial variability in stent types (i.e., balloon-expandable and self-expanding, with eight different models used), implantation techniques (e.g., suture-assisted delivery, sandwich techniques, and pulmonary vein protection strategies), procedural monitoring, and follow-up care. Anatomic heterogeneity among patients (e.g., bilateral superior vena cava, non-divertible accessory pulmonary veins) further

complicates standardization. Follow-up care was inconsistent, with a median duration of 1.7 years and many centers lacking longitudinal data beyond the initial postoperative visit. Of the 381 procedures performed, 13.4% of patients had formal MRI-based shunt quantification post-procedure. Limitations include retrospective design; no direct comparison with surgical repair; lack of standardized inclusion criteria, procedural protocols, and outcome definitions; as well as incomplete data capture and underreporting of complications. These factors underscore the need for prospective, controlled studies to evaluate safety, efficacy, and long-term outcomes before CSC can be considered a treatment option for sinus venosus ASDs.

A retrospective, single-center observational study (Brancato, et al., 2023) compared transcatheter (TC) versus surgical (SG) correction of isolated superior sinus venosus atrial septal defect (SVASD) with partial anomalous pulmonary venous drainage (PAPVD) in 58 patients treated between March 2010 and December 2020. Of these, 34 underwent transcatheter closure and 24 underwent surgical repair. Inclusion criteria included patients ≥ 14 years with SVASD and PAPVD, right heart enlargement, significant left-to-right shunt, or paradoxical embolism. Exclusion criteria included irreversible pulmonary vascular disease or need for concomitant intracardiac procedures. The intervention involved covered stent placement at the SVC-RA junction in the TC group, while the SG underwent patch repair or Warden procedure. Outcome measures included procedural success, ICU and hospital stay, early complications, residual shunt, right ventricular remodeling, and NYHA class improvement, with follow-up ranging from 1 to 90 months. The TC group had significantly shorter ICU ($p < 0.0001$) and hospital stays ($p < 0.0001$), and fewer early complications ($p = 0.005$). Both groups showed significant reductions in right ventricular end-diastolic volume (TC: $p < 0.00001$; SG: $p < 0.0001$). Residual shunts were mild and not significantly different between groups. Limitations include the non-randomized design, potential selection bias due to anatomical contraindications for TC in some SG patients, and variable follow-up durations.

Rosenthal et al. (2021) conducted a retrospective, multicenter international registry study to evaluate the safety and efficacy of the 10-zig covered Cheatham-platinum (CCP) stent for transcatheter correction of sinus venosus atrial septal defects (SVASD) with partial anomalous pulmonary venous drainage. A total of 75 patients (median age 45.4 years; range 11.4–75.9 years) underwent stent implantation across 12 centers. All patients received the 10-zig CCP stent as the intervention; there was no comparator arm. Inclusion criteria encompassed patients with anatomy deemed suitable for transcatheter correction based on imaging and balloon interrogation. Exclusion criteria were not uniformly defined across centers. Outcome measures included reduction in shunt fraction (QP:QS) and right ventricular end-diastolic volume index (RVEDVi), with statistically significant improvements observed post-procedure (QP:QS decreased from 2.5 ± 0.5 to 1.2 ± 0.36 and RVEDVi from 149.1 ± 35.4 to 95.6 ± 21.43 mL/m² (both $p < 0.001$)). Follow-up ranged from two months to 5.1 years (median 1.8 years). Additional stents were required in 32 patients (43%) to ensure stability or complete defect closure. Major complications occurred in 5.3% of patients, including stent embolization and pulmonary vein occlusion. Limitations include the non-uniform data collection across centers, lack of standardized imaging protocols, variable follow-up durations, and absence of a control group.

A retrospective observational cohort study by Hansen et al. (2020) evaluated the safety and efficacy of transcatheter correction of superior sinus venosus atrial septal defects (SVASD) with partial anomalous pulmonary venous drainage (PAPVD) as an alternative to surgical repair. Between March 2016 and September 2019, 48 adult patients were assessed; 25 underwent transcatheter stent implantation, 6 were awaiting treatment, and 17 were referred for surgery. The intervention involved placement of a covered Cheatham platinum stent in the superior vena cava (SVC) to redirect anomalous pulmonary venous flow to the left atrium, with balloon testing and multimodal imaging used to confirm anatomical suitability; there was no comparator arm. Inclusion criteria included adults ≥ 16 years with SVASD and PAPVD, right heart volume overload, and a pulmonary-to-systemic flow ratio $> 1.5:1$. Exclusion criteria included pulmonary veins

draining too high into the SVC or anatomy unsuitable for stent redirection. Outcome measures included procedural success, residual shunting, pulmonary venous obstruction, and right ventricular remodeling assessed via cardiac MRI. Successful implantation was achieved in 24 of the 25 individuals who underwent stent implantation with one individual experiencing stent embolization that required surgical removal and patch closure. Residual shunting was observed in 44% of patients by angiography and 60% by color Doppler echocardiography. At follow-up: Only one patient had a significant residual shunt at late follow-up, attributed to a small gap at the inferior stent margin and an additional RUPV draining into the high SVC. Cardiac MRI at 1 year showed a pulmonary-to-systemic flow ratio of 1.10:1 (IQR: 1.10–1.15), indicating minimal residual shunting. Median follow-up was 1.4 years, with significant reduction in indexed right ventricular end-diastolic volume ($p = 0.001$) and no late complications. Limitations include the single-center design, small sample size, absence of a randomized comparator arm, and short-to-medium follow-up duration (maximum 3.8 years), which precludes assessment of long-term safety and durability.

Professional Societies/Organizations: No major professional societies—including the American Heart Association (AHA), American College of Cardiology (ACC), Society for Cardiovascular Angiography and Interventions (SCAI), and Society for Vascular Surgery (SVS)—endorse the use of peripheral vascular stents for the closure of cardiovascular defects such as atrial septal defects (ASD), ventricular septal defects (VSD), or patent foramen ovale (PFO). The 2024 AHA/ACC Guidelines for the Management of Peripheral Artery Disease focus exclusively on peripheral arterial applications and do not address intracardiac use of these devices. The 2019 ACC/AHA guideline for the management of adults with congenital heart disease does not mention or endorse the use of peripheral stents for any type of cardiovascular defect. Similarly, SVS clinical practice guidelines evaluate peripheral stents only in the context of vascular disease management and do not support their use for congenital heart defect closure. SCAI’s guidelines for PFO management recommend FDA-approved septal occluder devices and make no mention of peripheral stents as a treatment option (Gornik, et al., 2025; SVS, 2025; Kavinsky, et al., 2022; Stout, et al., 2019).

Experimental, Investigational, Or Unproven

Perventricular/Transmyocardial Closure of Ventricular Septal Defects: The use of a perventricular approach, also referred to as a transmyocardial approach, has been explored as an alternative to the transcatheter approach for ventricular septal defect (VSD) closure. This hybrid approach has been investigated in the treatment of patients for whom transcatheter closure is challenging, including small infants and patients with poor vascular access. A perventricular approach was reported in five of 55 patients included in the first report of the multicenter CardioSEAL VSD registry. The registry was created following FDA approval of the CardioSEAL VSD Occluder in order to track the device’s safety in closing high-risk, complex, muscular VSD. The five patients who were treated with perventricular implantation all weighed ≤ 7 kg. Four of these procedures were reported to be successful by the implanting center. One perventricular implant failed because the right ventricular arms of the device protruded the right ventricular free wall (Lim, et al., 2007). There is insufficient evidence in the published medical literature to demonstrate the safety and efficacy of perventricular closure of VSD. In addition, no devices have received FDA approval for this application.

U.S. Food and Drug Administration (FDA): No septal occlusion devices have received FDA approval for perventricular/transmyocardial closure of ventricular septal defects.

Literature Review: There is insufficient evidence in published peer-reviewed scientific literature to support the safety and effectiveness of the perventricular/transmyocardial approach to VSD closure. The body of evidence is largely comprised of case series, observational studies, and cohort studies with a few small randomized controlled trials. The studies are limited by

heterogenous study designs, small patient populations, publication bias, and variability in the type of VSDs treated. Well-designed, randomized controlled studies are needed to determine the clinical utility of the periventricular/transmyocardial approach to VSD closure (Huan, et al., 2020; Li, et al., 2020; Hong, et al., 2019)

Bacha et al. (2005) described a periventricular hybrid approach, combining surgical and interventional techniques, utilized in a series 12 patients with muscular VSD. Using a sternotomy or subxyphoid approach, the right ventricle free wall was punctured under transesophageal echocardiography guidance. A guide wire was introduced across the largest defect, and a short delivery sheath was positioned in the left ventricle cavity. An Amplatzer muscular VSD occluder was deployed across the VSD. Cardiopulmonary bypass was required only for repair of concomitant lesions. At a median follow-up of 12 months, all patients were asymptomatic, and two patients had mild residual ventricular level shunts.

Health Equity Considerations

Health equity is the highest level of health for all people; health inequity is the avoidable difference in health status or distribution of health resources due to the social conditions in which people are born, grow, live, work, and age.

Social determinants of health are the conditions in the environment that affect a wide range of health, functioning, and quality of life outcomes and risks. Examples include safe housing, transportation, and neighborhoods; racism, discrimination and violence; education, job opportunities and income; access to nutritious foods and physical activity opportunities; access to clean air and water; and language and literacy skills.

Congenital heart defects are the most common types of birth defects and affect nearly 40,000 (1%) of births per year in the United States. They can be considered mild (e.g., small hole in the heart) or severe (e.g., missing or poorly formed cardiac anatomy). Examples of congenital heart defects include: atrial septal defect, Ebstein anomaly, single ventricle, ventricular septal defect. Depending on the severity of the defect, there may be no signs or symptoms at all. More severe defects may result in, for example, cyanosis, tachypnea, fatigue, or death. Some defects can be diagnosed during pregnancy with a fetal echocardiogram, however, some are not diagnosed until later in life. Treatment varies and is dependent on the severity of the defect (CDC, 2024).

Kaltman et al. (2020) found in a cross-sectional, population-based sample of birth and infant death data files from the National Center for Health Statistics at the Centers for Disease Control and Prevention that disparities exist in congenital heart disease infant mortality rates based upon the maternal proximity to a top 50 specialized pediatric cardiac center (PCC) (i.e., as reported by the U.S. News & World Report in 2017). The infant mortality rate for infants whose mothers lived proximal to a PCC (0.28/1000 live births) was significantly lower than the infant mortality rate for infants whose mothers did not live proximal to a PCC (0.37/1000 live births) ($p < 0.0001$). The infant mortality rate was 28% greater for infants whose mothers did not live proximal to a top 50 PCC compared to those infants whose mothers did. These findings suggest that geographic proximity to a specialized pediatric cardiac center contributes to the overall risk for infant mortality in those with congenital heart disease.

Between 1999 and 2017, congenital heart disease (CHD) mortality in the United States declined significantly—by 39.4% overall—reflecting advances in medical and surgical care. However, the study by Lopez et al. (2020) highlights persistent and troubling disparities in CHD mortality across racial/ethnic and gender lines. Non-Hispanic Black individuals consistently experienced higher CHD mortality rates than Non-Hispanic Whites, with the disparity worsening over time. For example,

the CHD mortality rate ratio between these groups increased from 1.24 in 1999 to 1.31 in 2017. Hispanic populations, who initially had lower CHD mortality than Non-Hispanic Whites, saw no improvement in infant CHD mortality over the last decade, resulting in equal mortality rates by 2017. Gender disparities were also evident, with males experiencing higher CHD mortality than females across all age groups, despite similar rates of decline.

Medicare Coverage Determinations

	Contractor	Determination Name/Number	Revision Effective Date
NCD	National	No National Coverage Determination found	
LCD		No Local Coverage Determination found	

Note: Please review the current Medicare Policy for the most up-to-date information.
(NCD = National Coverage Determination; LCD = Local Coverage Determination)

Levels of Scientific Evidence*

- Level 1. Randomized Controlled Trials (RCT). Randomized, blinded, placebo-controlled, clinical trials and systematic reviews of RCTs and meta-analysis of RCTs,
- Level 2. Non-randomized controlled trials (an experimental study, but not an ideal design). Also systematic reviews and meta-analyses of non-randomized controlled trials.
- Level 3. Observational studies – e.g. cohort, case-control studies (non-experimental studies). Also systematic reviews and meta-analyses of observational studies.
- Level 4. Descriptive studies, case reports, case series, panel studies (non-experimental studies), and retrospective analyses of any kind. Also systematic reviews and meta-analyses of retrospective studies.
- Level 5. Professional/organizational recommendations when based upon a valid evidence-based assessment of the available literature.

*Levels of Evidence Table adapted from the Centre for Evidence Based Medicine, University of Oxford, March 2009
(<https://www.cebm.net/2009/06/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/>)

References

1. Almekhlafi MA, Wilton SB, Rabi DM, Ghali WA, Lorenzetti DL, Hill MD. Recurrent cerebral ischemia in medically treated patent foramen ovale: a meta-analysis. *Neurology*. 2009 Jul 14;73(2):89-97.
2. Alnasser S, Lee D, Austin PC, Labos C, Osten M, Lightfoot DT, Kutty S, Shah A, Meier L, Benson L, Horlick E. Long term outcomes among adults post transcatheter atrial septal defect closure: Systematic review and meta-analysis. *Int J Cardiol*. 2018;270:126-132.
3. Anderson G, Ebersole D, Covington D, Denoble PJ. The effectiveness of risk mitigation interventions in divers with persistent (patent) foramen ovale. *Diving Hyperb Med*. 2019 Jun 30;49(2):80-87.
4. Arora R, Trehan V, Thakure AK, Mehta V, Sengupta PP, Nigam M. Transcatheter closure of congenital muscular ventricular septal defect. *J Interv Cardiol*. 2004 Apr;17(2):109-15.

5. Bacha EA, Cao Q-L, Galantowicz ME, Cheatham JP, Fleishman CE, Weinstein SW, et al. Multicenter experience with perventricular device closure of muscular ventricular septal defects. *Pediatr Cardiol*. 2005 Mar-Apr;26(2):169-75.
6. Baroutidou A, Arvanitaki A, Farmakis IT, Patsiou V, Giannopoulos A, Efthimiadis G, Ziakas A, Giannakoulas G. Transcatheter closure of atrial septal defect in the elderly: a systematic review and meta-analysis. *Heart*. 2023 Jun 28;heartjnl-2023-322529.
7. Berger F, Vogel M, Alexi-Meskishvili V, Lange PE. Comparison of results and complications of surgical and Amplatzer device closure of atrial septal defects. *J Thorac Cardiovasc Surg* 1999 Oct;118(4):674-8.
8. Bischoff AR, Jasani B, Sathanandam SK, Backes C, Weisz DE, McNamara PJ. Percutaneous Closure of Patent Ductus Arteriosus in Infants 1.5 kg or Less: A Meta-Analysis. *J Pediatr*. 2021 Mar;230:84-92.e14.
9. Brancato F, Stephenson N, Rosenthal E, Hansen JH, Jones MI, Qureshi S, Austin C, Speggorin S, Caner S, Butera G. Transcatheter versus surgical treatment for isolated superior sinus venosus atrial septal defect. *Catheter Cardiovasc Interv*. 2023 May;101(6):1098-1107. doi: 10.1002/ccd.30650. Epub 2023 Apr 1. PMID: 37002948.
10. Butera G, Carminati M, Chessa M, Piazza L, Mischeletti A, Negure G, et al. Transcatheter closure of perimembranous ventricular septal defects: early and long-term results. *J Am Coll Cardiol*. 2007 Sep 18;50(12):1189-95.
11. Butera G, DeRosa G, Chessa M, Piazza L, Delogu A, Frigolo A, Carninati M. Transcatheter closure of persistent ductus arteriosus with the Amplatzer duct occluder in very young symptomatic children. *Heart*. 2004 Dec;90(12):1467-70.
12. Carroll JD, Saver JL, Thaler DE, Smalling RW, Berry S, MacDonald LA, Marks DS, Tirschwell DL; RESPECT Investigators. Closure of patent foramen ovale versus medical therapy after cryptogenic stroke. *N Engl J Med*. 2013 Mar 21;368(12):1092-100.
13. CDC. About congenital heart defects (CHDs). Mar 18, 2025. Accessed Aug 28, 2025. Available at URL address: https://www.cdc.gov/heart-defects/about/?CDC_AAref_Val=https://www.cdc.gov/ncbddd/heartdefects/facts.html
14. Cen H, Peng B, Li J, Chen S, Sun P. Efficacy and safety of the Amplatzer Duct Occluder II for ventricular septal defect closure: a meta-analysis. *Kardiol Pol*. 2021 Apr 23;79(4):401-409.
15. Centers for Medicare and Medicaid Services (CMS). Medicare Coverage Database. Accessed Aug 26, 2025. Available at URL address: <https://www.cms.gov/medicare-coverage-database/search.aspx>
16. Chen L, Luo S, Yan L, Zhao W. A systematic review of closure versus medical therapy for preventing recurrent stroke in patients with patent foramen ovale and cryptogenic stroke or transient ischemic attack. *J Neurol Sci*. 2014 Feb 15;337(1-2):3-7.
17. Chessa M, Carminati M, Butera G, Bini RM, Drago M, Rosti L, et al. Early and late complications associated with transcatheter occlusion of secundum atrial septal defect. *J Am Coll Cardiol* 2002 Mar 20;39(6):1061-5.

18. de Hemptinne Q, Horlick EM, Osten MD, Millán X, Tadros VX, Pighi M, et al. Initial clinical experience with the GORE® CARDIOFORM ASD occluder for transcatheter atrial septal defect closure. *Catheter Cardiovasc Interv*. 2017 Jan 27.
19. Demkow M, Ruzyllo W, Kepka C, Pruszczyk P, Opuchlik A, Szyluk B, et al. Transcatheter closure of patent foramen ovale in patients with cryptogenic stroke. *Kardiol Pol*. 2004 Aug;61(8):101-9; discussion 109.
20. Dowson A, Mullen MJ, Peatfield R, Muir K, Khan AA, Wells C, et al. Migraine Intervention With STARFlex Technology (MIST) trial: a prospective, multicenter, double-blind, sham-controlled trial to evaluate the effectiveness of patent foramen ovale closure with STARFlex septal repair implant to resolve refractory migraine headache. *Circulation*. 2008 Mar 18;117(11):1397-404.
21. Du ZD, Koenig P, Cao QL, Waight D, Heitschmidt M, Hijazi ZM. Comparison of transcatheter closure of secundum atrial septal defect using the Amplatzer septal occluder associated with deficient versus sufficient rims. *Am J Cardiol* 2002 Oct 15;90(8):865-9.
22. ECRI. Amplatzer Piccolo Occluder (Abbott) for Treating Patent Ductus Arteriosus. Evidence Analysis. Published date: Apr 29, 2019. Revised date: Jun 8, 2023.
23. Fischer G, Stieh J, Uebing A, Hoffman U, Morf G, Kramer HH. Experience with transcatheter closure of secundum atrial septal defects using the Amplatzer septal occluder: a single centre study in 236 consecutive patients. *Heart* 2003 Feb;89(2):199-204.
24. Furlan AJ, Reisman M, Massaro J, Mauri L, Adams H, Albers GW, et al.; CLOSURE I Investigators. Closure or medical therapy for cryptogenic stroke with patent foramen ovale. *N Engl J Med*. 2012 Mar 15;366(11):991-9.
25. Ghaderian M, Shahsanaei F, Behdad S, Shirvani E. Long-Term Outcome After Transcatheter Atrial Septal Defect Closure in Adults: A Systematic Review and Meta-Analysis. *Curr Probl Cardiol*. 2021 Mar;46(3):100595.
26. Goff DA, Blume ED, Gauvreau K, Mayer JE, Lock JE, Jenkins KJ. Clinical outcome of fenestrated Fontan patients after closure: the first 10 years. *Circulation*. 2000 Oct 24;102(17):2094-9.
27. Gornik HL, Aronow HD, Goodney PP, Arya S, Brewster LP, Byrd L, Chandra V, Drachman DE, Eaves JM, Ehrman JK, Evans JN, Getchius TSD, Gutiérrez JA, Hawkins BM, Hess CN, Ho KJ, Jones WS, Kim ESH, Kinlay S, Kirksey L, Kohlman-Trigoboff D, Long CA, Pollak AW, Sabri SS, Sadwin LB, Secemsky EA, Serhal M, Shishehbor MH, Treat-Jacobson D, Wilkins LR; Peer Review Committee Members. 2024 ACC/AHA/AACVPR/APMA/ABC/SCAI/SVM/SVN/SVS/SIR/VESS Guideline for the Management of Lower Extremity Peripheral Artery Disease: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *Circulation*. 2024 Jun 11;149(24):e1313-e1410. doi: 10.1161/CIR.0000000000001251. Epub 2024 May 14. Erratum in: *Circulation*. 2025 Apr 8;151(14):e918. doi: 10.1161/CIR.0000000000001329. PMID: 38743805.

28. Gruenstein DH, Ebeid M, Radtke W, Moore P, Holzer R, Justino H. Transcatheter closure of patent ductus arteriosus using the AMPLATZER™ duct occluder II (ADO II). *Catheter Cardiovasc Interv.* 2017 May;89(6):1118-1128.
29. Guyatt GH, Akl EA, Crowther M, Schünemann HJ, Gutterman DD, Lewis SZ. Introduction to the ninth edition: antithrombotic therapy and prevention of thrombosis, 9th ed: american college of chest physicians evidence-based clinical practice guidelines. Feb 2012. *Chest*, Vol. 141, Issue 2, p48S–52S.
30. Hansen JH, Duong P, Jivanji SGM, Jones M, Kabir S, Butera G, Qureshi SA, Rosenthal E. Transcatheter Correction of Superior Sinus Venosus Atrial Septal Defects as an Alternative to Surgical Treatment. *J Am Coll Cardiol.* 2020 Mar 24;75(11):1266-1278. doi: 10.1016/j.jacc.2019.12.070. PMID: 32192652.
31. Harms V, Reisman M, Fuller CJ, Spencer MP, Olsen JV, Krabill KA, et al. Outcomes after transcatheter closure of patent foramen ovale in patients with paradoxical embolism. *Am J Cardiol.* 2007 May 1;99(9):1312-5.
32. Hayes, Inc. Hayes Health Technology Brief. Gore cardioform septal occluder (W.L. Gore & Associates) for closure of atrial septal defects. Hayes, Inc.: Nov 30, 2017. Annual review Dec 12, 2019. Accessed Sep 14, 2020.
33. Hayes, Inc. Hayes Comparative Effectiveness Review. Transcatheter closure of patent foramen ovale for the prevention of recurrent cryptogenic stroke. Hayes, Inc.: May 31, 2018. Annual review Jun 27, 2019. Accessed Sep 14, 2020.
34. Honěk J, Šrámek M, Honěk T, Tomek A, Šefc L, Januška J, Fiedler J, Horváth M, Novotný Š, Veselka J. Patent Foramen Ovale Closure Is Effective in Divers: Long-Term Results From the DIVE-PFO Registry. *J Am Coll Cardiol.* 2020 Sep 1;76(9):1149-1150.
35. Hong ZN, Chen Q, Huang LQ, Cao H. A meta-analysis of periventricular device closure of perimembranous ventricular septal defect. *J Cardiothorac Surg.* 2019 Jun 27;14(1):119.
36. Kaltman J, Burns Kristin, Pearson G, Goff D, Evans F. Disparities in congenital heart disease mortality based on proximity to a specialized pediatric cardiac center. *Circulation.* 2020;141:1034–1036.
37. Kavinsky CJ, Szerlip M, Goldswig AM, Zahid A, Konstantinos DM, Carroll J, Coylewright M, Elmariah S, MacDonald LA, Shah AP, Spies C, Tobis JM, Messe SR, Senerth E, Falck-Ytter Y, Babatunde I, Morgan R. SCAI guidelines for the management of patient foramen ovale. *Journal of the Society for Cardiovascular Angiography & Interventions.* Volume 1, issue 4, 100039, July 01, 2022.
38. Kheiri B, Abdalla A, Osman M, Ahmed S, Hassan M, Bachuwa G. Patent foramen ovale closure versus medical therapy after cryptogenic stroke: An updated meta-analysis of all randomized clinical trials. *Cardiol J.* 2019;26(1):47-55.
39. Kleindorfer DO, Towfighi A, Chaturvedi S, Cockcroft KM, Gutierrez J, Lombardi-Hill D, Kamel H, Kernan WN, Kittner SJ, Leira EC, Lennon O, Meschia JF, Nguyen TN, Pollak PM, Santangeli P, Sharrief AZ, Smith SC Jr, Turan TN, Williams LS. 2021 Guideline for the Prevention of Stroke in Patients With Stroke and Transient Ischemic Attack: A Guideline From the American Heart Association/American Stroke Association. *Stroke.* 2021 Jul;52(7):e364-e467.

40. Koopsen R, Stella PR, Thijs KM, Rienks R. Persistent foramen ovale closure in divers with a history of decompression sickness. *Neth Heart J*. 2018 Nov;26(11):535-539.
41. Lee PH, Song JK, Kim JS, Heo R, Lee S, Kim DH, et al. Cryptogenic Stroke and High-Risk Patent Foramen Ovale: The DEFENSE-PFO Trial. *J Am Coll Cardiol*. 2018 May 22;71(20):2335-2342.
42. Li D, Zhou X, Li M, An Q, et al. Comparisons of periventricular device closure, conventional surgical repair, and transcatheter device closure in patients with perimembranous ventricular septal defects: a network meta-analysis. *BMC Surg*. 2020;20(1):115.
43. Lim DS, Forbes TJ, Rohman A, Lock JE, Landzberg MJ. Transcatheter closure of high-risk muscular ventricular septal defects with the CardioSEAL occluder: Initial report from the CardioSEAL VSD Registry. *Catheter Cardiovasc Interv*. 2007 Jul 9.
44. Lopez KN, Morris SA, Sexson Tejtzel SK, Espallat A, Salemi JL. US Mortality Attributable to Congenital Heart Disease Across the Lifespan From 1999 Through 2017 Exposes Persistent Racial/Ethnic Disparities. *Circulation*. 2020 Sep 22;142(12):1132-1147. doi: 10.1161/CIRCULATIONAHA.120.046822. Epub 2020 Aug 3. PMID: 32795094; PMCID: PMC7508797.
45. Mas JL, Derumeaux G, Guillon B, Massardier E, Hosseini H, Mechtouff L, et al; CLOSE Investigators. Patent Foramen Ovale Closure or Anticoagulation vs. Antiplatelets after Stroke. *N Engl J Med*. 2017 Sep 14;377(11):1011-1021.
46. Masura J, Gao W, Gavora P, Sun K, Zhou AQ, Jiang S, et al. Percutaneous closure of perimembranous ventricular septal defects with the eccentric Amplatzer device: multicenter follow-up study. *Pediatr Cardiol*. 2005 May-Jun;26(3):216-9.
47. Mattle HP, Evers S, Hildick-Smith D, Becker WJ, Baumgartner H, Chataway J, Gawel M, Göbel H, Heinze A, Horlick E, Malik I, Ray S, Zermansky A, Findling O, Windecker S, Meier B. Percutaneous closure of patent foramen ovale in migraine with aura, a randomized controlled trial. *Eur Heart J*. 2016 Jul 7;37(26):2029-36.
48. Mattle HP, Meier B, Nedeltchew. Prevention of stroke in patients with patent foramen ovale. *Int J Stroke*. 2010 Apr;5(2):92-102.
49. Meier B, Kalesan B, Mattle HP, Khattab AA, Hildick-Smith D, Dudek et al., PC Trial Investigators. Percutaneous closure of patent foramen ovale in cryptogenic embolism. *N Engl J Med*. 2013 Mar 21;368(12):1083-91.
50. Messe SR, Gronseth GS, Kent DM, Kizer JR, Homma S, Rosterman S, Carroll JD, Ishida K, Sangha N, Kasner SE. Practice advisory update summary: Patent foramen ovale and secondary stroke prevention. Report of the Guideline Subcommittee of the American Academy of Neurology. *Neurology* 2020;94:876-885.
51. Mojadidi MK, Kumar P, Mahmoud AN, Elgendy IY, Shapiro H, West B, Charles AC, Mattle HP, Sorensen S, Meier B, Silberstein SD, Tobis JM. Pooled Analysis of PFO Occluder Device Trials in Patients With PFO and Migraine. *J Am Coll Cardiol*. 2021 Feb 16;77(6):667-676.

52. Nasir UB, Qureshi WT, Jogu H, Wolfe E, Dutta A, Majeed CN, Tan WA. Updated meta-analysis of closure of patent foramen ovale versus medical therapy after cryptogenic stroke. *Cardiovasc Revasc Med*. 2019 Mar;20(3):187-193.
53. O'Gara PT, Messe SR, Tuzcu EM, Catha G, Ring JC; American Heart Association; American Stroke Association; American College of Cardiology Foundation. Percutaneous device closure of patent foramen ovale for secondary stroke prevention: a call for completion of randomized clinical trials. A science advisory from the American Heart Association/American Stroke Association and the American College of Cardiology Foundation. *J Am Coll Cardiol*. 2009 May 26;53(21):2014-8.
54. Pass RH, Hijazi Z, Hsu, DT, Lewis V, Hellenbrand WE. Multicenter USA Amplatzer patent ductus arteriosus occlusion device trial: initial and one-year results. *J Am Coll Cardiol*. 2004 Aug 4;44(3):513-9.
55. Pearman A, Bugeja L, Nelson M, Szantho GV, Turner MS. An audit of persistent foramen ovale closure in 105 divers. *Diving and Hyperbaric Medicine*. 2015 June; 45(2): 94-97.
56. Riaz H, Khan MS, Schenone AL, Waheed AA, Khan AR, Krasuski RA. Transcatheter closure of patent foramen ovale following cryptogenic stroke: An updated meta-analysis of randomized controlled trials. *Am Heart J*. 2018;199:44-50.
57. Rosenthal E, Qureshi SA, Jones M, Butera G, Sivakumar K, Boudjemline Y, Hijazi ZM, Almaskary S, Ponder RD, Salem MM, Walsh K, Kenny D, Hascoet S, Berman DP, Thomson J, Vettukattil JJ, Zahn EM. Correction of sinus venosus atrial septal defects with the 10 zig covered Cheatham-platinum stent - An international registry. *Catheter Cardiovasc Interv*. 2021 Jul 1;98(1):128-136. doi: 10.1002/ccd.29750. Epub 2021 May 7. PMID: 33909945.
58. Rosenthal E, Qureshi SA, Sivakumar K, Jones M, Yong SF, Kabir S, Sagar P, Thejaswi P, Hascoet S, Batteux C, Boudjemline Y, Hijazi ZM, Aboulhosn JA, Levi DS, Salem MM, Francis E, Kempny A, Fraisse A, Bautista-Rodriguez C, Walsh K, Kenny D, Traynor B, Al Maskari SN, Bentham JR, Környei L, Sivaprakasam MC, Firouzi A, Khajali Z, Benson L, Osten M, Baruteau AE, Crystal MA, Forbes TJ, Georgiev S, Sievert H, Tin DN, Springmuller D, Subramanian A, Abdullah HAM, Bedair R, Chamié F, Celebi A, Damsky Barbosa J, De Meester P, Giugno L, Jalal Z, Karsenty C, Schleiger A, Fleming G, Jakob A, Karagoaz T, Mainzer G, Morgan GJ, Narin N, Shahanavaz S, Steinberg ZL, Aldoss O, Alizade E, Aregullin O, Bouvaist H, Fleck T, Godart F, Malekzadeh-Milani S, Motta P, Sanchez-Recalde A, Sandoval JP, Tan W, Thomson J, Tomé Teixeira P, Zahn EM. Covered Stent Correction for Sinus Venosus Atrial Septal Defects, an Emerging Alternative to Surgical Repair: Results of an International Registry. *Circulation*. 2025 Mar 18;151(11):744-756. doi: 10.1161/CIRCULATIONAHA.124.070271. Epub 2024 Dec 19. PMID: 39697167; PMCID: PMC11913232.
59. Sacco RL, Adams R, Albers G, Alberts MJ, Benavente O, Furie K. et al.; American Heart Association; American Stroke Association Council on Stroke; Council on Cardiovascular Radiology and Intervention; American Academy of Neurology. Guidelines for prevention of stroke in patients with ischemic stroke or transient ischemic attack: a statement for healthcare professionals from the American Heart Association/American Stroke Association Council on Stroke: co-sponsored by the Council on Cardiovascular Radiology and Intervention: the American Academy of Neurology affirms the value of this guideline. *Stroke*. 2006 Feb;37(2):577-617.

60. Sathanandam SK, Gutfinger D, O'Brien L, Forbes TJ, Gillespie MJ, Berman DP, Armstrong AK, Shahanavaz S, Jones TK, Morray BH, Rockefeller TA, Justino H, Nykanen DG, Zahn EM. Amplatzer Piccolo Occluder clinical trial for percutaneous closure of the patent ductus arteriosus in patients ≥ 700 grams. *Catheter Cardiovasc Interv*. 2020 Nov;96(6):1266-1276.
61. Saver JL, Carroll JD, Thaler DE, Smalling RW, MacDonald LA, Marks DS, Tirschwell DL; RESPECT Investigators. Long-Term Outcomes of Patent Foramen Ovale Closure or Medical Therapy after Stroke. *N Engl J Med*. 2017 Sep 14;377(11):1022-1032.
62. Schwedt tTJ, Demaerschalk BM, Dodick DW. Patent foramen ovale and migraine: a quantitative systematic review. *Cephalalgia*. 2008 May;28(5):531-40.
63. Smith B, Thomson J, Crossland D, Spence MS, Morgan GJ. UK multicenter experience using the Gore septal occluder (GSO(TM)) for atrial septal defect closure in children and adults. *Catheter Cardiovasc Interv*. 2014 Mar 1;83(4):581-6.
64. Society for Vascular Surgery (SVS). Clinical practice guidelines. 2025. Accessed Aug 27, 2025. Available at URL address: <https://vascular.org/vascular-specialists/practice-and-quality/clinical-guidelines/clinical-guidelines-and-reporting>
65. S ndergaard L, Kasner SE, Rhodes JF, Andersen G, Iversen HK, Nielsen-Kudsk JE, et al; Gore REDUCE Clinical Study Investigators. Patent Foramen Ovale Closure or Antiplatelet Therapy for Cryptogenic Stroke. *N Engl J Med*. 2017 Sep 14;377(11):1033-1042.
66. Stout KK, Daniels CJ, Aboulhosn JA, Bozkurt B, Broberg CS, Colman JM, Crumb SR, Dearani JA, Fuller S, Gurm V, Khairy P, Landzberg MJ, Saidi A, Valente AM, Van Hare GF. 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. *J Am Coll Cardiol*. 2019 Apr 2;73(12):e81-e192. doi: 10.1016/j.jacc.2018.08.1029. Epub 2018 Aug 16. Erratum in: *J Am Coll Cardiol*. 2019 May 14;73(18):2361-2362. doi: 10.1016/j.jacc.2019.03.018. PMID: 30121239.
67. Tobis JM, Charles A, Silberstein SD, Sorensen S, Maini B, Horwitz PA, Gurley JC. Percutaneous Closure of Patent Foramen Ovale in Patients With Migraine: The PREMIUM Trial. *J Am Coll Cardiol*. 2017 Dec 5;70(22):2766-2774.
68. Turner DR, Owada CY, Sang CJ Jr, Khan M, Lim DS. Closure of Secundum Atrial Septal Defects With the AMPLATZER Septal Occluder: A Prospective, Multicenter, Post-Approval Study. *Circ Cardiovasc Interv*. 2017 Aug;10(8).
69. Turner ME, Bouhout I, Petit CJ, Kalfa D. Transcatheter Closure of Atrial and Ventricular Septal Defects: JACC Focus Seminar. *J Am Coll Cardiol*. 2022 Jun 7;79(22):2247-2258.
70. U. S. Food and Drug Administration (FDA). Guidance document: non-clinical engineering tests and recommended labeling for intravascular stents and associated delivery systems - guidance for industry and FDA staff. April 2010. Content current as of: Jun 29, 2018. Accessed Aug 27, 2025. Available at URL address: <https://www.fda.gov/regulatory-information/search-fda-guidance-documents/non-clinical-engineering-tests-and-recommended-labeling-intravascular-stents-and-associated-delivery>

71. U. S. Food and Drug Administration (FDA). Listing of CDRH Humanitarian Device Exemptions. Content current as of: May 29, 2024b. Accessed Aug 29, 2025. Available at URL address:
<http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/DeviceApprovalsandClearances/HDEApprovals/ucm161827.htm>
72. U. S. Food and Drug Administration (FDA). Investigational Device Exemption (IDE). Content current as of: Aug 22, 2024c. Accessed Aug 29, 2025. Available at URL address:
<http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/HowtoMarketYourDevice/InvestigationalDeviceExemptionIDE/default.htm>
73. U. S. Food and Drug Administration (FDA). PMA-Premarket Approval database. Product codes: MLV, MAE, OZG. Page last updated: Aug 18, 2025. Accessed Aug 28, 2025. Available at URL address:
<http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMA/pma.cfm>
74. Vaduganathan M, Qamar A, Gupta A, Bajaj N, Golwala HB, Pandey A, Bhatt DL. Patent Foramen Ovale Closure for Secondary Prevention of Cryptogenic Stroke: Updated Meta-Analysis of Randomized Clinical Trials. *Am J Med*. 2018 May;131(5):575-577.
75. Wang YL, Wang FZ, Zhang Y, Jiang J, Jia Z, Liu X, Wang J, Xu J. Association of migraine with patent foramen ovale closure: A systematic review and meta-analysis. *Int J Cardiol Heart Vasc*. 2022 Mar 18;39:100992.
76. Webb GD, Smallhorn JF, Therrien J, Reddington AN. In: Part IX. Diseases of the Myocardium, Pericardium and Pulmonary Vasculature Bed. *Braunwald's heart disease: a textbook of cardiovascular medicine*, 11th ed. Saunders, an imprint of Elsevier, 2019. Ch 75.
77. Webb GD, Smallhorn JF, Therrien J, Reddington AN. In: Part VIII. Diseases of the Heart, Pericardium, and Pulmonary Vasculature Bed. *Congenital Heart Disease. Braunwald's heart disease: a textbook of cardiovascular medicine*, 10th ed. Saunders, an imprint of Elsevier, 2015. Ch 62. 1391-1445.
78. Weryński P, Skorek P, Wójcik A, Rudek-Budzyńska S, Dziewulska A, Rudziński A. Recent achievements in transcatheter closure of ventricular septal defects: a systematic review of literature and a meta-analysis. *Kardiologia Polska*. 2021; 79 (2): 161-169
79. Yang J, Yang L, Wan Y, Zuo J, Zhang J, Chen W, et al. Transcatheter device closure of perimembranous ventricular septal defects: mid-term outcomes. *Eur Heart J*. 2010 Sep;31(18):2238-45.
80. Yang X, Yu Z, Wang Y, Ding Y, Ni R, Xiao P. Transcatheter closure for postinfarction ventricular septal defect: A meta-analysis of the current evidence. *J Card Surg*. 2021 Dec;36(12):4625-4633.
81. Zhang QQ, Lu JJ, Yan MY, Hu XW, Qin YR, Wang DP, Jiang JH, Fang Q, Zhao HR. The Efficacy of Percutaneous Patent Foramen Ovale Closure on Migraine: a Meta-Analysis of Randomized Controlled Trials and Observational Studies. *Biomed Res Int*. 2021 Mar 4;2021:6643266.
82. Zhang Y, Wang H, Liu L. Patent Foramen Ovale Closure for Treating Migraine: A Meta-Analysis. *J Interv Cardiol*. 2022 Feb 2;2022:6456272.

Revision Details

Type of Revision	Summary of Changes	Date
Annual Review	Added policy statement for the use of any device not approved by the FDA for the indication of cardiovascular defect closure.	11/15/2025
Annual Review	- Revised policy statement for ventricular septal defects. - Revised policy statement for 'transcatheter closure of CVD for any other indication' and 'closure of ostium primum or sinus venosus ASDs'.	11/15/2024
Annual Review	No policy statement changes.	11/15/2023

"Cigna Companies" refers to operating subsidiaries of The Cigna Group. All products and services are provided exclusively by or through such operating subsidiaries, including Cigna Health and Life Insurance Company, Connecticut General Life Insurance Company, Evernorth Behavioral Health, Inc., Cigna Health Management, Inc., and HMO or service company subsidiaries of The Cigna Group®. 2025 The Cigna Group.