

Protocol

Total Artificial Hearts and Implantable Ventricular Assist Devices

(70311)

Medical Benefit		Effective Date: 07/01/15	Next Review Date: 05/21
Preauthorization	No	Review Dates: 01/10, 01/11, 01/12, 01/13, 05/13, 05/14, 05/15, 05/16, 05/17, 05/18, 05/19, 11/19, 05/20	

Preauthorization is not required.

The following protocol contains medical necessity criteria that apply for this service. The criteria are also applicable to services provided in the local Medicare Advantage operating area for those members, unless separate Medicare Advantage criteria are indicated. If the criteria are not met, reimbursement will be denied and the patient cannot be billed. Please note that payment for covered services is subject to eligibility and the limitations noted in the patient's contract at the time the services are rendered.

Populations	Interventions	Comparators	Outcomes
Individuals: • With end-stage heart failure	Interventions of interest are: • Ventricular assist device as bridge to heart transplant	Comparators of interest are: • Optimal medical therapy	Relevant outcomes include: • Overall survival • Symptoms • Functional outcomes • Quality of life • Treatment-related mortality • Treatment-related morbidity
Individuals: • With end-stage heart failure	Interventions of interest are: • Ventricular assist device as destination therapy	Comparators of interest are: • Optimal medical therapy	Relevant outcomes include: • Overall survival • Symptoms • Functional outcomes • Quality of life • Treatment-related mortality • Treatment-related morbidity
Individuals: • With end-stage heart failure	Interventions of interest are: • Total artificial heart as bridge to transplant	Comparators of interest are: • Optimal medical therapy	Relevant outcomes include: • Overall survival • Symptoms • Functional outcomes • Quality of life • Treatment-related mortality • Treatment-related morbidity
Individuals: • With end-stage heart failure	Interventions of interest are: • Total artificial heart as destination therapy	Comparators of interest are: • Optimal medical therapy	Relevant outcomes include: • Overall survival • Symptoms • Functional outcomes • Quality of life • Treatment-related mortality • Treatment-related morbidity
Individuals: • With cardiogenic shock	Interventions of interest are: • Percutaneous ventricular assist device	Comparators of interest are: • Intra-aortic balloon pump	Relevant outcomes include: • Overall survival • Symptoms • Morbid events • Functional outcomes

Populations	Interventions	Comparators	Outcomes
			<ul style="list-style-type: none"> Quality of life Treatment-related mortality Treatment-related morbidity
Individuals: <ul style="list-style-type: none"> Who undergo high-risk cardiac procedures 	Interventions of interest are: <ul style="list-style-type: none"> Percutaneous ventricular assist device 	Comparators of interest are: <ul style="list-style-type: none"> Intra-aortic balloon pump 	Relevant outcomes include: <ul style="list-style-type: none"> Overall survival Symptoms Morbid events Functional outcomes Quality of life Treatment-related mortality Treatment-related morbidity
Individuals: <ul style="list-style-type: none"> With cardiogenic shock refractory to intra-aortic balloon pump 	Interventions of interest are: <ul style="list-style-type: none"> Percutaneous ventricular assist device 	Comparators of interest are: <ul style="list-style-type: none"> Optimal medical therapy Other mechanical circulatory support 	Relevant outcomes include: <ul style="list-style-type: none"> Overall survival Symptoms Change in disease status Functional outcomes Quality of life Treatment-related mortality Treatment-related morbidity

DESCRIPTION

A ventricular assist device (VAD) is mechanical support attached to the native heart and vessels to augment cardiac output. The total artificial heart (TAH) replaces the native ventricles and is attached to the pulmonary artery and aorta; the native heart is typically removed. Both the VAD and TAH may be used as a bridge to heart transplantation or as destination therapy in those not candidates for transplantation. The VAD has also been used as a bridge to recovery in patients with reversible conditions affecting cardiac output.

SUMMARY OF EVIDENCE

VENTRICULAR ASSIST DEVICE

For individuals who have end-stage heart failure who receive a VAD as a bridge to transplant, the evidence includes single-arm trials and observational studies. The relevant outcomes are overall survival (OS), symptoms, functional outcomes, quality of life (QOL), and treatment-related mortality and morbidity. There is a substantial body of evidence from clinical trials and observational studies supporting implantable VADs as a bridge to transplant in patients with end-stage heart failure, possibly reducing mortality as well as improving QOL. These studies have reported that substantial numbers of patients have survived to transplant in situations in which survival would not be otherwise expected. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have end-stage heart failure who receive a VAD as destination therapy, the evidence includes a trial and multiple single-arm studies. The relevant outcomes are OS, symptoms, functional outcomes, QOL, and treatment-related mortality and morbidity. A well-designed trial, with two years of follow-up data, has demonstrated an advantage of implantable VADs as destination therapy for patients ineligible for a heart transplant. Despite an increase in adverse events, both mortality and QOL appear to be improved for these patients. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

TOTAL ARTIFICIAL HEART

For individuals who have end-stage heart failure who receive a TAH as a bridge to transplant, the evidence includes case series. The relevant outcomes are OS, symptoms, functional outcomes, QOL, and treatment-related mortality and morbidity. Compared with VADs, the evidence for TAHs in these settings is less robust. However, given the lack of medical or surgical options for these patients and the evidence case series provide, TAH is likely to improve outcomes for a carefully selected population with end-stage biventricular heart failure awaiting transplant who are not appropriate candidates for a left VAD. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have end-stage heart failure who receive a TAH as destination therapy, the evidence includes two case series. The relevant outcomes are OS, symptoms, functional outcomes, QOL, and treatment-related mortality and morbidity. The body of evidence for TAHs as destination therapy is too limited to draw conclusions. The evidence is insufficient to determine the effects of the technology on health outcomes.

PERCUTANEOUS VENTRICULAR ASSIST DEVICE

For individuals with cardiogenic shock or who undergo high-risk cardiac procedures who receive a pVAD, the evidence includes randomized controlled trials (RCTs), observational studies, and systematic reviews. The relevant outcomes are OS, symptoms, morbid events, functional outcomes, QOL, and treatment-related mortality and morbidity. Four RCTs of pVAD vs. intra-aortic balloon pump for patients in cardiogenic shock failed to demonstrate a mortality benefit and reported higher complication rates with pVAD use. Comparative observational studies were consistent with the RCT evidence. RCTs, controlled and uncontrolled observational studies, and systematic reviews of these studies have not demonstrated a benefit of pVAD used as ancillary support for patients undergoing high-risk cardiac procedures. The evidence is insufficient to determine the effects of the technology on health outcomes.

For individuals with cardiogenic shock refractory to intra-aortic balloon pump therapy who receive a pVAD, the evidence includes case series. The relevant outcomes are OS, symptoms, morbid events, functional outcomes, QOL, and treatment-related mortality and morbidity. Case series of patients with cardiogenic shock refractory to intra-aortic balloon pump have reported improved hemodynamic parameters following pVAD placement. However, these uncontrolled series do not provide evidence that pVADs improve mortality, and high rates of complications have been reported with pVAD use. The evidence is insufficient to determine the effects of the technology on health outcomes.

POLICY

BRIDGE TO TRANSPLANTATION

Implantable ventricular assist devices (VADs) with Food and Drug Administration (FDA) approval or clearance may be considered **medically necessary** as a bridge to heart transplantation for patients who are currently listed as heart transplantation candidates and not expected to survive until a donor heart can be obtained, or are undergoing evaluation to determine candidacy for heart transplantation.

Implantable VADs with FDA approval or clearance, including humanitarian device exemptions, may be considered **medically necessary** as a bridge to heart transplantation in children 16 years old or younger who are currently listed as heart transplantation candidates and not expected to survive until a donor heart can be obtained, or are undergoing evaluation to determine candidacy for heart transplantation.

Total artificial hearts (TAHs) with FDA-approved devices may be considered **medically necessary** as a bridge to heart transplantation for patients with biventricular failure who have no other reasonable medical or surgical treatment options, who are ineligible for other univentricular or biventricular support devices, and are currently

listed as heart transplantation candidates or are undergoing evaluation to determine candidacy for heart transplantation, and not expected to survive until a donor heart can be obtained.

DESTINATION THERAPY

Implantable VADs with FDA approval or clearance may be considered **medically necessary** as destination therapy with end-stage heart failure patients who are ineligible for human heart transplant and who meet the following REMATCH Study criteria:

- New York Heart Association (NYHA) class IV heart failure for 60 or more days, OR patients in NYHA class III or IV for 28 days, received 14 or more days of support with intra-aortic balloon pump or dependent on intravenous inotropic agents, with two failed weaning attempts.

In addition, patients must not be candidates for human heart transplant for one or more of the following reasons:

- Age greater than 65 years; OR
- Insulin-dependent diabetes mellitus with end-organ damage; OR
- Chronic renal failure (serum creatinine greater than 2.5 mg/dL for 90 or more days); OR
- Presence of other clinically significant condition.

POSTCARDIOTOMY SETTING/BRIDGE TO RECOVERY

- Implantable VADs with FDA approval or clearance may be considered **medically necessary** in the postcardiotomy setting in patients who are unable to be weaned off cardiopulmonary bypass

OTHER INDICATIONS

Other applications of implantable VADs or TAHs are considered **investigational**, including, but not limited to, the use of TAHs as destination therapy. The use of non-FDA approved or cleared implantable VADs or TAHs is considered **investigational**.

Percutaneous VADs are considered **investigational** for all indications.

POLICY GUIDELINES

Only two VADs have approval from the U.S. Food and Drug Administration (FDA) for the pediatric population. The DeBakey VAD® Child device and the Berlin Heart EXCOR Pediatric VAD have FDA approval through the humanitarian device exemption (HDE) process. The DeBakey VAD is indicated for use in children ages five to 16 years who are awaiting a heart transplant (i.e., a bridge to transplant) while the Berlin Heart EXCOR VAD is indicated for children with severe isolated left ventricular or biventricular dysfunction who are candidates for cardiac transplant and require circulatory support.

In general, candidates for bridge-to-transplant implantable VADs are those who are considered appropriate heart transplant candidates but who are unlikely to survive the waiting period until a human heart donor is available. Some studies have included the following hemodynamic selection criteria: either a left atrial pressure of 20 mm Hg or a cardiac index of less than 2.0 L/min/m while receiving maximal medical support. Patients with VADs are classified by the United Network for Organ Sharing as Status I (i.e., persons who are most ill and are considered the highest priority for transplant).

The median duration for time on the device is between 20 and 120 days.

Contraindications for bridge to transplant VADs and TAHs include conditions that would generally exclude patients for heart transplant. Such conditions are chronic irreversible hepatic, renal, or respiratory failure; sys-

temic infection; coagulation disorders and inadequate psychosocial support. Due to potential problems with adequate function of the VAD or TAH, implantation is also contraindicated in patients with uncorrected valvular disease. See also the Heart Transplant Protocol for further discussion of heart transplant candidacy.

In addition, patients must have sufficient space in the thorax and/or abdominal cavity for the device. In the case of the CardioWest™ temporary Total Artificial Heart, this excludes patients with body surface areas less than 1.7 m² or who have a distance between the sternum and 10th anterior rib of less than 10 cm as measured by computed tomography scan.

MEDICARE ADVANTAGE

VADs

VADs are **medically necessary** postcardiotomy (following open-heart surgery). They must have received approval from the Food and Drug Administration (FDA) for that purpose, and they are used according to the FDA-approved labeling instructions.

VADs are **medically necessary** as bridge-to-transplant. They must have received approval from the FDA for that purpose, and be used according to the FDA-approved labeling instructions. All of the following criteria must also be met in order for a VAD to be **medically necessary** as a bridge-to-transplant:

- a. The patient is approved for heart transplantation by a Medicare-approved heart transplant center and is active on the Organ Procurement and Transplantation Network (OPTN) heart transplant waitlist,
- b. The implanting site, if different than the Medicare-approved transplant center, must receive written permission from the Medicare-approved heart transplant center under which the patient is listed prior to implantation of the VAD.

VADs used for destination therapy are **medically necessary** only if they have received approval from the FDA for that purpose, and the device is used according to the FDA-approved labeling instructions.

VADs are **medically necessary** for patients who have chronic end-stage heart failure (New York Heart Association Class IV end-stage left ventricular failure) who are not candidates for heart transplantation, and meet all of the following conditions:

- a. Have failed to respond to optimal medical management (including beta-blockers and ACE inhibitors if tolerated) for 45 of the last 60 days, or have been balloon pump-dependent for seven days, or IV (intravenous) inotrope-dependent for 14 days; and,
- b. Have a left ventricular ejection fraction (LVEF) less than 25%, and,
- c. Have demonstrated functional limitation with a peak oxygen consumption of 14 ml/kg/min or less unless balloon pump- or inotrope-dependent or physically unable to perform the test.

ARTIFICIAL HEARTS

An artificial heart may have potential to be covered when performed under coverage with evidence development (CED) for the following indications:

- 1) bridge to transplant (BTT)
- 2) destination therapy (DT).

MEDICARE ADVANTAGE POLICY GUIDELINES

FACILITY CRITERIA

Facilities which are approved to provide VAD as destination therapy are listed at this web site:

<https://www.cms.gov/Medicare/Medicare-General-Information/MedicareApprovedFacilities/VAD-Destination-Therapy-Facilities.html>.

Prospective VAD recipients must receive all information and support necessary to participate in shared decision making and to provide appropriate informed consent.

BACKGROUND

HEART FAILURE

Heart failure may be the consequence of a number of etiologies, including ischemic heart disease, cardiomyopathy, congenital heart defects, or rejection of a heart transplant. The reduction of cardiac output is considered to be severe when systemic circulation cannot meet the body's needs under minimal exertion. Heart transplantation improves quality of life and has survival rates at one, three, and five years of about 91%, 85%, and 78%, respectively.¹ The number of candidates for transplants exceeds the supply of donor organs; thus the interest in the development of mechanical devices.

Treatment

Ventricular Assist Devices

Implantable VADs are attached to the native heart, which may have enough residual capacity to withstand a device failure in the short term. In reversible heart failure conditions, the native heart may regain some function, and weaning and explanting of the mechanical support system after months of use has been described. VADs can be classified as internal or external, electrically or pneumatically powered, and pulsatile or continuous-flow. Initial devices were pulsatile, mimicking the action of a beating heart. More recent devices may use a pump, which provides continuous flow. Continuous devices may move blood in a rotary or axial flow.

At least one VAD system developed is miniaturized and generates an artificial pulse, the HeartMate 3 Left Ventricular Assist System.²

Surgically implanted VADs represent a method of providing mechanical circulatory support for patients not expected to survive until a donor heart becomes available for transplant or for whom transplantation is contraindicated or unavailable. VADs are most commonly used to support the left ventricle but right ventricular and biventricular devices may be used. The device is larger than most native hearts, and therefore the size of the patient is an important consideration; the pump may be implanted in the thorax or abdomen or remain external to the body. Inflow to the device is attached to the apex of the failed ventricle, while outflow is attached to the corresponding great artery (aorta for the left ventricle, a pulmonary artery for the right ventricle). A small portion of the ventricular wall is removed for insertion of the outflow tube; extensive cardiomy affecting the ventricular wall may preclude VAD use.

Total Artificial Hearts

Initial research into mechanical assistance for the heart focused on the TAH, a biventricular device that completely replaces the function of the diseased heart. An internal battery required frequent recharging from an external power source. Many systems use a percutaneous power line, but a transcutaneous power-transfer coil allows for a system without lines traversing the skin, possibly reducing the risk of infection. Because the native heart must be removed, failure of the device is synonymous with cardiac death.

A fully bioprosthetic TAH, which is fully implanted in the pericardial sac and is electro-hydraulically actuated, has been developed and tested in two patients but is currently experimental.³

Percutaneous VADs

Devices in which most of the system's components are external to the body are for short-term use (six hours to 14 days) only, due to the increased risk of infection and need for careful, in-hospital monitoring. Some circulatory assist devices are placed percutaneously (i.e., are not implanted). They may be referred to as pVADs. A pVAD is placed through the femoral artery. Two different pVADs have been developed, the TandemHeart and the Impella device. In the TandemHeart System, a catheter is introduced through the femoral vein and passed into the left atrium via transeptal puncture. Oxygenated blood is then pumped from the left atrium into the arterial system via the femoral artery. The Impella device is introduced through a femoral artery catheter. In this device, a small pump is contained within the catheter placed into the left ventricle. Blood is pumped from the left ventricle, through the device, and into the ascending aorta. Adverse events associated with pVAD include access site complications such as bleeding, aneurysms, or leg ischemia. Cardiovascular complications can also occur, such as perforation, myocardial infarction, stroke, and arrhythmias.

REGULATORY STATUS

A number of mechanical circulatory support devices have been approved or cleared for marketing by the U.S. Food and Drug Administration (FDA). These devices are summarized in Tables 1 and 2 and discussed in the following sections.

Table 1. Available Mechanical Circulatory Support Devices

Device	Manufacturer	Approval Date	FDA Clearance	PMA, HDE, or 510(k) No.	Indication
Thoratec IVAD	Thoratec	Aug 2004	PMA Supp	P870072	Bridge to transplant and postcardiotomy
DeBakey VAD® Child	MicroMed	Feb 2004	HDE	H030003	Bridge to transplant in children 5-16 y
HeartMate II	Thoratec	Apr 2008	PMA	P060040	Bridge to transplant and destination
CentriMag	Levitronix (now Thoratec)	Oct 2008	HDE	H070004	Postcardiotomy
Berlin Heart EXCOR® Pediatric VAD	Berlin	Dec 2011	HDE	H100004	Bridge to transplant
HeartWare® Ventricular Assist System	HeartWare	Dec 2012	PMA	P100047	Bridge to transplant
HeartMate 3 Left Ventricular Assist System	Thoratec	Aug 2017	PMA	P160054	Bridge to transplant
		Oct 2018	PMA	P160054/S008	Destination

FDA: U.S. Food and Drug Administration; HDE: humanitarian device exemption; PMA: premarket approval.

VENTRICULAR ASSIST DEVICES

In 1995, the Thoratec® Ventricular Assist Device System (Thoratec Corp.) was approved by the FDA through the premarket approval process as a bridge to transplantation in patients with end-stage heart failure. The patient should meet all of the following criteria:

- candidate for cardiac transplantation,
- imminent risk of dying before donor heart procurement, and
- dependence on, or incomplete response to, continuous vasopressor support.

In 1998, supplemental approval for this device was given for the indication of postcardiotomy patients unable to be weaned from cardiopulmonary bypass. In June 2001, supplemental approval was given for a portable external driver to permit excursions within a two-hour travel radius of the hospital when accompanied by a trained caregiver. In 2003, supplemental approval was given to market the device as Thoratec® Paracorporeal VAD. In 2004, supplemental approval was given to a modified device to be marketed as the Thoratec® Implantable VAD for the same indications. In 2008, supplemental approval was given to rescind Paracorporeal VAD use.

In August 2016, HeartWare® recalled its VAD Pumps due to a design flaw that was deemed by the FDA as potentially causing serious injuries or death (class I recall). The devices affected were manufactured and distributed from March 2006 and May 2018. FDA product codes 204 and 017.

A class I recall was issued for the HeartMate 3™ in April 2018 affecting all manufacturing dates. FDA product code: DSQ.

TOTAL ARTIFICIAL HEART

In 2004, the temporary CardioWest™ Total Artificial Heart (SynCardia Systems) was approved by the FDA through the premarket approval process for use as a bridge to transplant in cardiac transplant-eligible candidates at risk of imminent death from biventricular failure. This device is also intended for use inside the hospital. In 2010, the FDA approved a name change to SynCardia Temporary Total Artificial Heart. FDA product code: LOZ.

In 2006, the AbioCor® Implantable Replacement Heart System (Abiomed) was approved by FDA through the humanitarian device exemption (H040006) process in severe biventricular end-stage heart disease patients who are not cardiac transplant candidates and who:

- are younger than 75 years of age;
- require multiple inotropic support;
- are not treatable by left VAD destination therapy; and
- are not weanable from biventricular support if on such support.

In addition to meeting other criteria, patients who are candidates for the AbioCor® TAH must undergo a screening process to determine if their chest volume is large enough to hold the device. The device is too large for approximately 90% of women and for many men.

PERCUTANEOUS VADS (CIRCULATORY ASSIST DEVICES)

Table 2. Available Mechanical Circulatory Support Devices

Device	Manufacturer	Approval Date	FDA Clearance	PMA, 510(k) No.	Indication
TandemHeart®	Cardiac Assist	Sep 2005	510(k)	K110493	Temporary left ventricular bypass of ≤6 h
Impella® Recover LP 2.5	Abiomed	May 2008	510(k)	K063723	Partial circulatory support using extracorporeal bypass control unit for ≤6 h
Impella 2.5 System	Abiomed	Mar 2015	PMA	P140003	Temporary ventricular support for ≤6 h

FDA: U.S. Food and Drug Administration; PMA: premarket approval.

COMPARATIVE EFFICACY OF LEFT VAD DEVICES

The mechanism of operation of left VADs has changed since their introduction. The earliest devices were pulsatile positive displacement pumps. These pumps have been largely replaced by axial continuous-flow pumps. More recently centrifugal continuous-flow pumps have also been introduced.

The evidence of the comparative efficacy of centrifugal continuous-flow vs. axial continuous-flow devices consists of two randomized controlled trials of two different centrifugal continuous-flow devices.^{4,5} The MOMENTUM 3 trial compared HeartMate 3 centrifugal continuous-flow device with the HeartMate II axial continuous-

flow device in patients indicated for circulatory support as a bridge to transplant or destination therapy. HeartMate 3 received PMA approval as a bridge to transplant therapy in August 2017 and as destination therapy in October 2018. The destination therapy indication was based on two-year results from MOMENTUM 3, which showed superiority of the HeartMate 3 device compared to HeartMate II on the composite primary outcome, survival at two years free of disabling stroke or reoperation to replace a malfunctioning device (relative risk 0.84; 95% confidence interval 0.78–0.91, $p < 0.001$).⁶ Prevalence of stroke at two years was lower in the HeartMate 3 than the HeartMate 2 group (10.1% vs. 19.2%; $P = 0.02$).⁷ Measures of functional capacity and Health-Related Quality of Life did not differ between the two devices at six months.⁸ The ENDURANCE trial compared HeartWare centrifugal continuous-flow device with the HeartMate II axial continuous-flow device in patients indicated for circulatory support as destination therapy. HeartWare is FDA-approved as a bridge to transplantation device. Both trials found the centrifugal device to be noninferior to the axial device for the primary, composite outcome including measures of survival, freedom from disabling stroke, and freedom from device failure. While there are fewer device failures with the centrifugal devices without a significant increase in disabling stroke, the HeartWare device was associated with increased risk of any stroke over a period of two years.

The evidence on the comparative efficacy of continuous-flow vs. pulsatile-flow devices consists of a randomized controlled trial and several nonrandomized comparative studies.⁹⁻¹³ The randomized controlled trial reported fairly large differences in a composite outcome measure favoring the continuous-flow devices, with increases in revision and reoperation rates for the pulsatile device group being the largest factor driving the difference in outcomes. Other nonrandomized comparative studies, including a database study with large numbers of patients, have not reported important differences in clinical outcomes between devices.

RELATED PROTOCOLS

Heart Transplant

Heart/Lung Transplant

Services that are the subject of a clinical trial do not meet our Technology Assessment and Medically Necessary Services Protocol criteria and are considered investigational. *For explanation of experimental and investigational, please refer to the Technology Assessment and Medically Necessary Services Protocol.*

It is expected that only appropriate and medically necessary services will be rendered. We reserve the right to conduct prepayment and postpayment reviews to assess the medical appropriateness of the above-referenced procedures. **Some of this protocol may not pertain to the patients you provide care to, as it may relate to products that are not available in your geographic area.**

REFERENCES

We are not responsible for the continuing viability of web site addresses that may be listed in any references below.

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