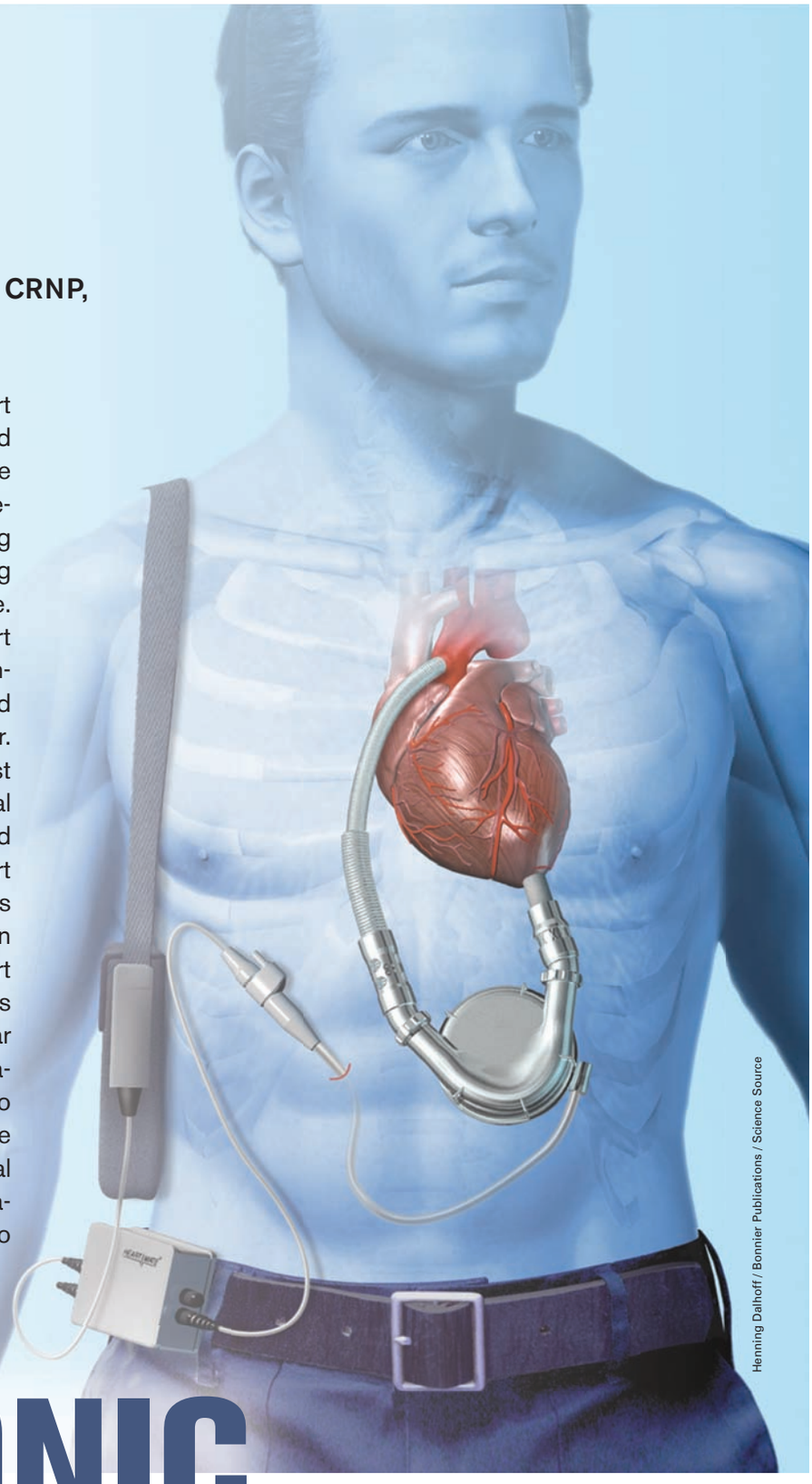
CE 1.5 HOURS
Continuing Education

Theresa Capriotti, DO, MSN, CRNP, and Morgan Micari

The prevalence of chronic heart failure is increasing in the United States due to the increase in the number of older adults and because many people are surviving acute cardiac events and living longer with chronic heart disease. In end-stage heart failure, heart transplant was once the gold standard of treatment and patients had to wait for a matching heart donor. In the past, the left ventricular assist device (LVAD) was a mechanical circulatory support treatment used temporarily for those awaiting heart transplant. However, the LVAD is increasingly becoming the chosen treatment of patients in lieu of heart transplant. Home healthcare nurses and clinicians need to be familiar with LVADs in order to care for patients in end-stage heart failure who are using these devices. This article explains the mechanism, potential complications, and nursing implications of caring for the patient who is using an LVAD.



Henning Dalhoff / Bonnier Publications / Science Source

CHRONIC HEART FAILURE TREATMENT

With the Left Ventricular Assist Device

Heart failure (HF) is a chronic disease with progressive deterioration occurring over years or decades. It is currently a public health problem that can be viewed as an epidemic affecting 5.8 million persons in the United States and 30 million persons worldwide. Every year 550,000 individuals are diagnosed with HF and there is a 1 in 5 lifetime risk of developing this chronic syndrome (Centers for Disease Control and Prevention, n.d.). The rising incidence of HF is due to increased survival after cardiac insults such as myocardial infarction, life-sustaining medical treatment of cardiovascular (CV) disorders, and the aging of the population (Liu & Eisen, 2014). People are increasingly surviving into old age after CV interventions such as coronary angioplasty, stent placement, and coronary artery bypass grafts. In contrast to other forms of CV disease such as myocardial infarction and coronary artery disease which are decreasing, the incidence, prevalence, and mortality from HF are increasing (Mozaffarian et al., 2016). By 2030, it is estimated there will be at least a 25% increase in prevalence of HF (Raj & Adhyaru, 2016).

The most common diagnosis in hospitalized patients over age 65 is HF (van Riet et al., 2014). Despite advances in therapy and management, HF is responsible for high rates of hospitalization, readmission rates, and mortality; nearly 40% of patients die within 1 year of their first hospitalization (DeVore et al., 2014). HF costs the nation an estimated $30.7 billion each year. This includes the cost of healthcare services, medications to treat HF, and missed days of work (Heidenreich et al., 2011).

Stages of HF

The American College of Cardiology and American Heart Association have developed a conceptual framework to help healthcare professionals understand the continuum of disease progression in four stages. Stage A is diagnosed in those who are at high risk for HF but without structural heart disease or symptoms of HF, such as patients with hypertension, atherosclerosis disease, or diabetes mellitus. Stage B includes those who have structural heart disease but without signs or symptoms of HF, such as patients with myocardial infarction and left ventricular remodeling. These patients have never had an episode of symptomatic HF. Stage C includes those who have structural heart disease with prior or current symptoms of HF, such as known structural heart disease and shortness of breath and fatigue. Stage D is the category for those who have end-stage HF and marked symptoms at rest despite maximal medical therapy (Jessup et al., 2009; Yancy et al., 2013).

In stage D, specialized intervention and treatment are required including options of compassionate end-of-life care/hospice, heart transplant, permanent mechanical support, experimental surgery, or drugs (Becnel et al., 2017). Heart transplant is the gold standard for treatment of end-stage HF; however, many sufferers wait months to years for a matching donor organ (Scientific Registry of Transplant Recipients, n.d.). The left ventricular assist device is an increasingly used option for patients in Stage D HF to prolong life in lieu of heart transplant.

Indications for a Left Ventricular Assist Device

In 1994, the ventricular assist device was approved as a temporary method to support cardiac function until cardiac transplantation could be completed. Ventricular assist devices were mainly used as a bridge to cardiac transplant for patients awaiting a donor heart. Ventricular assist devices are available as right ventricular, biventricular, or left ventricular assist devices (LVAD). The LVAD has become the most commonly implanted device to support patient cardiac function and circulation while awaiting transplant (Blair, 2018). Sajgalik et al. (2016) reported that among end-stage HF patients, those on LVADs showed a 48% reduction in death rate compared with similar patients on medical therapy alone.

Because of their success, LVAD use has expanded to now include "destination therapy." Destination therapy indicates that LVADs are approved for primary therapy in patients with end-stage HF as a final means of prolonging life (Starrh & Becker, 2018). Destination therapy, or the use of LVAD support until end of life, is the fastest growing use of LVAD therapy and the most

Destination therapy, or the use of left ventricular assist device (LVAD) support until end of life, is the fastest growing use of LVAD therapy and the most common reason for implantation in recent years.

common reason for implantation in recent years (INTERMACS, 2018). LVADs are now approved for use in three different clinical conditions:

- bridge to cardiac transplant;
- bridge to recovery in potentially reversible cardiac pathology;
- destination therapy, long-term support for patients ineligible for transplant.

There have been 25,114 mechanical circulatory support devices placed between 2006 and 2018, with a current pace of over 2,500 devices implanted per year (INTERMACS, 2018). As patients implanted with LVADs become more numerous and live longer, nurses in home care will likely encounter and care for a patient with an LVAD.

The Mechanism of an LVAD

There are two categories of LVAD devices, pulsatile and continuous flow devices. The first generation of LVAD devices were mainly pulsatile, creating intermittent arterial pulses of blood flow that mimicked systole and diastole. Most devices implanted now are continuous flow devices due to better portability, lower rate of complications, and the longer life span of this device. These devices provide continuous blood flow at a set speed. The HeartWare and the Heart Mate II models are currently the FDA-approved and most commonly used LVADs (Starrh & Becker, 2018). All LVADs consist of an inflow cannula that takes blood from the apex of the heart in the left ventricle, enters the LVAD pump, and pushes blood through an outflow cannula in the aorta, right above the aortic valve and out through the body. Continuous flow devices push blood through the heart continuously with a rotor, providing a steady stream of blood flow out of the heart into the aorta (O'Shea et al., 2013).

Parameters to Monitor

Important values that need to be monitored on a continuous-flow LVAD are pump speed, pump flow, pulsatile index, and pump power. The pump speed is a fixed number, set by the LVAD team, which measures how fast the rotor of the pump spins. The speed is determined by hemodynamic and echocardiographic measurements and is set in revolutions per minute. The pump flow is an approximation of the blood flow through the LVAD, estimated based on pump speed and power. The pump flow is representative of the patient's cardiac output in liters per minute. Pulsatile index is related to the amount of ventricular contractility and ventricular filling of the patient's heart. Pump power is the power needed by the pump to run at the right speed. The pump power is a measure of voltage and current power consumption of the pump. A change in speed, flow, or physiologic demand can affect power (Birati & Rame, 2014; Chmielinski & Koons, 2017).

Parameters are displayed on a controller worn on a belt by the patient. The parameters should only be manipulated by a specialist LVAD healthcare provider who is familiar with the device and the patient's clinical picture. The LVAD controller regulates power, monitors LVAD performance, and collects data on system operation. The controller sends power and operating signals through the driveline. The driveline is connected to the pump on one end, exits the patient's body at the chest or abdomen region, and connects to the external controller on the other end (Birati & Rame, 2014). LVADs are highly dependent on adequate preload which is the volume of blood in the left ventricle. A reduction in preload is caused by hypovolemia which can be due to dehydration, overdiuresis, bleeding, or right ventricular dysfunction (Starrh & Becker, 2018).

Diagnostic Testing Prior to Implantation of LVAD

There are many preliminary diagnostic tests needed before the implantation of an LVAD. The patient has to be diagnosed with end-stage HF which is refractory to medical management. The patient has to be in need of a cardiac transplant or LVAD for circulatory support to sustain life. The biomarkers B-type natriuretic peptide (BNP) or NT-proBNP, which are indicators of HF, should be elevated (Bowers, 2013). Patients can also be eligible for LVAD if their blood type or body size, or age makes them ineligible for a cardiac transplant, or if the wait for a donor organ will be prolonged (Sajgalik et al., 2016).

There are many criteria for eligibility of placement of an LVAD. Increased age, comorbidities, and fragility increase risk for complications. Patients who have cancer, active infections, or history of bleeding disorders may be ineligible for implantation of LVAD. Nutritional status is also an important consideration. Obesity does not prohibit implantation of LVAD, but patients are advised to lose weight for best results (Sajgalik et al., 2016).

Evaluation of eligible patients includes echocardiogram, left and right heart catheterization, pulmonary function tests, computed tomographic (CT) scan, and blood tests. Patients need a whole team of professionals to care for them, and a strong support system at home is essential. The patient also needs to be motivated to make lifestyle changes that accompany living with an LVAD (Blair, 2018).

Potential Complications Associated With LVAD

Thrombosis

Patients with LVADs have an increased risk of thrombosis because the LVAD is foreign material in constant contact with the bloodstream. Patients are maintained on anticoagulation (usually warfarin) and antiplatelet therapy (usually aspirin) (Nicholson & Kaakeh, 2018). The international normalized ratio (INR) goal is between 1.5 and 2.5 (Eckman & John, 2012). Patients who develop a thrombus may present with signs of HF. Also because of shear forces inside the LVAD motor, signs of hemolysis may be apparent. The LVAD has an alarm that sounds when increased resistance is sensed within the circuit (Jennings & Weeks, 2015). Echocardiogram and CT scan can be used to confirm the presence of a thrombus. Serial lactate dehydrogenase measurements are monitored in the patient as this lab test can indicate the formation of a thrombus prior to symptoms. In the case of thrombosis, additional medical treatment such as heparin, glycoprotein 2b/3a antagonists, or tissue plasminogen activator may be necessary (Baumannn Kreuziger et al., 2015).

Infection

The current LVAD design is not a completely closed system as there is an open driveline exit. Trauma to this percutaneous exit site is a common cause for infection (Schaffer et al., 2011). The patient may have a variety of symptoms depending on the severity of the infection. The driveline exit site may demonstrate purulent drainage or abscess. The patient's condition can rapidly progress to sepsis and/or shock (Nienaber et al., 2013). Treatment involves establishing hemodynamic stability. Blood culture and imaging tests are necessary to evaluate for internal abscess or vegetation in or around the device. Common pathogens include *Staphylococcus, Pseudomonas*, and *Candida.* The patient should be treated with appropriate antibiotics and may require long-term suppressive antibiotic therapy. Fluid resuscitation is also required as the LVAD is highly dependent on adequate ventricular filling volume to prevent hypovolemia (Topkara et al., 2010).

Gastrointestinal Bleeding

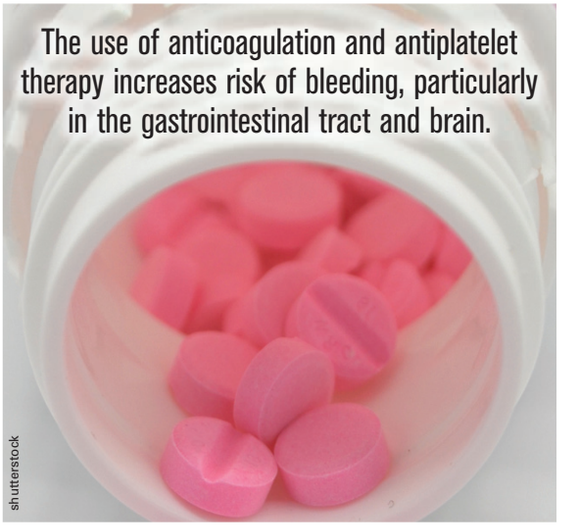
The use of anticoagulation and antiplatelet therapy increases risk of bleeding, particularly in the gastrointestinal tract and brain. Also, chronic anticoagulation can lead to platelet dysfunction or acquired Von Willebrand disease. There is also an increased prevalence of arteriovenous malformations in patients with LVADs. The exact mechanism is unknown, although it is theorized that blood vessels undergo remodeling under the influence of abnormal continuous blood flow created by the LVAD (Demirozu et al., 2011). Patients may report black stool, incontinence due to blood in stool, or mental status changes. In severe cases, patients will demonstrate hypotension, hypovolemic shock, and rectal bleeding. Patients may report LVAD alarm signals related to hypovolemia such as high power, low flow, or low pulsatile index (Harvey et al., 2014).

Stroke

Patients with LVADs are at increased risk for both ischemic and hemorrhagic stroke. Acute ischemic strokes result from thromboembolic events due to pump thrombosis, subtherapeutic anticoagulation, or a prothrombotic state associated with activation of the immune system. Because thrombosis is associated with LVADs, a clot can form and be ejected out of the outflow tract into the aorta and travel up to the brain. Alternatively, patients on long-term anticoagulation are at increased risk for hemorrhagic stroke (Parikh et al., 2016). The INR for therapeutic anticoagulation should ideally be maintained between 1.5 and 2.5. Hemorrhagic stroke can occur in these patients due to hemorrhagic transformation of an ischemic stroke, overanticoagulation, or infection.

Right HF

After LVAD implantation, there is increased output from the left ventricle that can lead to right ventricle failure (RVF) (Birati & Rame, 2014). The patient may exhibit jugular vein distension, ascites, hepatic congestion, and/or peripheral edema. An echocardiogram and laboratory testing for liver enzymes are indicated if RVF is suspected



(Turner, 2019). It can be treated with diuretics and modification of LVAD parameters. In severe cases, mechanical support of the right ventricle may be required with a biventricular assist device.

Ventricular Dysrhythmias

LVAD-induced ventricular dysrhythmias can occur if the patient has a preload deficiency with decreased filling of the left ventricle due to hypovolemia. With diminished left ventricular filling, the inflow cannula can become drawn down into the cardiac ventricular tissue. The cannula's contact with the cardiac tissue can irritate the area and trigger a ventricular dysrhythmia. These dysrhythmias tend to be short and are repeated until the hypovolemia is corrected. Common causes of hypovolemia and preload deficiency include sepsis, hemorrhage, and right ventricular failure (Pedretti et al., 2017). Ventricular dysrhythmias can lead to cardiac arrest. Advanced cardiac life support measures that include chest compressions can be used in patients with LVADs.

Implications for Home Care Clinicians

To provide care to these patients, clinicians need to be able to properly assess patients with the LVADs, understand basic LVAD technology, and recognize potential complications. Patients with an LVAD are instructed on how their device operates while in the hospital. They are discharged from the hospital to independently manage their health with the device at home, but they should have a solid plan for 24-hour caregiver support in place. They will be closely monitored by an LVAD team who access to the data coming from the device. LVAD teams are typically made up of cardiac surgeons, cardiologists, and nurses who specialize in caring for these patients. The LVAD team will notify the local emergency department and first responders when the patient is discharged. It is wise for the patient to also make contact with local first responders to inquire about the availability of back-up generators in times of power outages.

Physical examination of the patient with an LVAD is similar to assessment of a patient without a LVAD with a few exceptions. Nonpulsatile LVADs provide continuous blood flow so patients have a weak or absent palpable pulse. This can cause difficulty obtaining a blood pressure with a traditional cuff. A Doppler blood pressure device can be used to verify arterial blood flow in the extremities (Birati & Rame, 2014). Because of the sounds of the LVAD, auscultating heart and lung sounds can be difficult. To listen to breath sounds, posterior auscultation is recommended for accurate assessment. An LVAD hum can be heard anteriorly, which is consistent with normal function of the device. Sounds that are harsh, grating, or variable in quality can be indicative of a complication such as LVAD clotting (Starrh & Becker, 2018).

Prevention, Assessment, and Treatment of Infection

A significant cause of morbidity and mortality in patients with an LVAD is infection. The percutaneous driveline is the most common site of infection as it acts as a port of entry where pathogens can enter and travel deeper into tissues (Angud, 2015). Patients should not shower until instructed by their surgeon. Typically, driveline infections present with signs of exit-site cellulitis, such as spreading erythema and warmth. Sterile technique should always be used when performing LVAD site care. Initially, the frequency of dressing changes is determined by the LVAD providers; dressing changes are usually done daily, then decreased in frequency to every other day. The patient or caregiver should be instructed on sterile technique and the home care clinician should observe the caregiver or patient complete the dressing change to ensure their correct understanding of the procedure. If a driveline infection is suspected, the dressing changes are increased to daily (Chmielinski & Koons, 2017). Culture of the driveline site is necessary. Either oral or intravenous antibiotic therapy will be started depending on the severity

of the infection. Daily sterile dressing changes using chlorhexidine has been reported in the literature (Angud, 2015). The driveline should be stabilized with an abdominal binder to minimize disruption of the driveline exit site and the site should be kept dry (Nienaber et al., 2013). If patients have erythema, purulent drainage, or a temperature above 100.4° F (38° C), they should notify their LVAD center and go to the nearest hospital as directed. Many LVAD teams ask patients to take a photo of their driveline site and send it to them to evaluate and determine the severity of the infection (Chmielinski & Koons).

If a serious infection is suspected, patients designated as bridge to transplant should be transferred to a transplant center because an infection can elevate a patient's status on the transplant waiting list. Deep driveline infections may require prolonged intravenous antimicrobial therapy in conjunction with possible debridement and wound vacuum-assisted closure therapy or pump replacement (Angud, 2015). There is risk of the pathogen developing antibiotic resistance. In some cases, the infection can become refractory to the antibiotic. In these cases, the LVAD will have to be removed. Infection can quickly progress to sepsis and septic shock. Management of these patients is similar to patients without LVADs. The heart is supported by the LVAD; therefore, intravenous fluids can be administered and are usually well tolerated because the device provides the pumping action (Starrh & Becker, 2018). However, patients with LVAD can develop right HF, so fluid infusion should be done with caution. Volume overload can occur (Topkara et al., 2010).

Gastrointestinal Bleeding

Gastrointestinal (GI) bleeding is the most common adverse event and a frequent cause for early post-transplant hospital readmission in LVAD patients. Studies show that 15% to 61% of the patients develop GI hemorrhage after LVAD implantation (Gurvits & Frakov, 2017). Management of patients with GI bleeding consists of reversing anticoagulation and treating hypovolemia with fluids and blood products. However, transfusion should be avoided if possible in patients awaiting transplant. A blood transfusion can sensitize the patient and cause antibody formation that will complicate successful cardiac transplantation (Baumann Kreuziger et al., 2015). Anticoagulation can be reversed with fresh frozen plasma and vitamin K.

Dysrhythmias

Patients with an LVAD are at high risk for atrial and ventricular dysrhythmias. The incidence of ventricular dysrhythmias among patients with an LVAD ranges from 22% to 52% (Cesario et al., 2011). Patients with sustained ventricular tachycardia may present with feelings of palpitations, chest pain, fatigue, or nausea (Starrh & Becker, 2018). Management of atrial dysrhythmias in patients with an LVAD is similar to patients without an LVAD. For rate control, beta-blockers are preferred. If beta-blockers are not well tolerated, amiodarone is preferred for atrial dysrhythmias (Chmielinski & Koons, 2017). Most patients with an LVAD have an implantable cardioverter defibrillator (ICD). The ICD may terminate the ventricular dysrhythmias with antitachycardia pacing or internal shocks (Cesario et al.). If patients have received internal shocks, they may develop anxiety due to a catecholamine surge that occurs with defibrillation. This can predispose the patient to additional episodes of ventricular tachycardia (Chmielinski & Koons).

Stroke

Patients with an LVAD are at increased risk for ischemic and hemorrhagic strokes (Cho et al., 2017). Patients and caregivers should be taught "FAST," the mnemonic used to remember the signs of a stroke: **F**acial drooping, **A**rm weakness, **S**peech difficulties, and **T**ime to call 9-1-1. If a patient presents with signs or symptoms of stroke, they should present to the emergency department for an immediate CT scan to determine type of stroke. Note that patients with LVADs cannot undergo magnetic resonance imaging due to the metal components of the VAD.

Critical Alarms

Healthcare providers caring for patients with LVADs should understand critical alarms that can sound. Critical alarms are most commonly due to pump failure, low battery, controller failure, or low flow (Sen et al., 2016). In the case of pump failure, potential causes include driveline disconnection or breakage, electrical failure, or connector malfunction. Assess the connection from the driveline, controller, and power source. For a low battery alarm, ensure that the LVAD is connected to either battery or AC power. Make sure the battery charger is plugged in and at least two backup batteries are charging. To correct controller failure, the controller must be changed. Patients should have a spare controller that is preprogrammed and LVAD

coordinators can offer directions (Chmielinski & Koons, 2017). A low-flow alarm may occur due to hypovolemia, bleeding, tamponade, RVF, hypertension, or cannula obstruction (Sen et al.). In the event of LVAD alarms, contact the LVAD coordinators or physicians caring for the patient.

End-of-Life Issues

Healthcare providers need to discuss end-of-life care for patients with an LVAD. Preplanning for end-of-life issues and an advanced directive are critical for patients with an LVAD. The Joint Commission requires that palliative care be integrated into the care plan of patients implanted with an LVAD (Salomon et al., 2018). If complications arise that are refractory to treatment, the LVAD may need to be explanted. In cases of complications, some patients may elect to have their device turned off because of life-limiting illness that causes poor quality of life. When the patient or surrogate decides to deactivate the device, it isn't considered physician-assisted suicide—it is considered a natural death (Chmielinski & Koons, 2017). Palliative care specialists are critical to provide education, guidance, and support to patient, family, caregivers, and clinicians from implantation of the LVAD to end of life.

Conclusion

LVADs are increasingly used to improve quality of life for end-stage HF patients. Initially developed as a bridge to transplantation, LVADs are now also offered to patients ineligible for transplantation as destination therapy. An individual with a destination LVAD will live the remainder of their life with the device in place. Although survival and quality of life improve with LVADs compared with medical therapy, complications can occur including thrombosis, bleeding, infection, and stroke. With increasing numbers of patients opting for LVAD treatment, in lieu of cardiac transplantation, home care clinicians will need to be familiar with the mechanism and healthcare issues involved with this device. ⌂

Theresa Capriotti, DO, MSN, CRNP, is a Clinical Associate Professor, Fitzpatrick College of Nursing, Villanova University, Villanova, Pennsylvania.

Morgan Micari is an Honors student, Fitzpatrick College of Nursing, Villanova University, Villanova, Pennsylvania.

The authors declare no conflicts of interest.

Address for correspondence: Teri Capriotti, DO, MSN, CRNP, Villanova University, 800 Lancaster Avenue, Villanova, PA 19085 (theresa.capriotti@villanova.edu).

DOI:10.1097/NHH.0000000000000777

REFERENCES

Angud, M. (2015). Left ventricular assist device driveline infections: The Achilles' heel of destination therapy. *AACN Advanced Critical Care, 26*(4), 300-305. doi:10.1097/NCI.0000000000000108

Baumann Kreuziger, L. M., Kim, B., & Wieselthaler, G. M. (2015). Antithrombotic therapy for left ventricular assist devices in adults: A systematic review. *Journal of Thrombosis and Haemostasis, 13*(6), 946-955.

Becnel, M. F., Ventura, H. O., & Krim, S. R. (2017). Changing our approach to stage D heart failure. *Progress in Cardiovascular Diseases, 60*(2), 205-214. doi:10.1016/j.pcad.2017.08.003

Birati, E. Y., & Rame, J. E. (2014). Left ventricular assist device management and complications. *Critical Care Clinics, 30*(3), 607-627. doi:10.1016/j.ccc.2014.04.001

Blair, A. (2018). The use of left ventricular assist devices in end-stage heart failure. *Critical Care Nursing Quarterly, 41*(4), 376-382. doi:10.1097/CNQ.0000000000000223

Centers for Disease Control and Prevention. (n.d.). Retrieved from https://www.cdc.gov/

Cesario, D. A., Saxon, L. A., Cao, M. K., Bowdish, M., & Cunningham, M. (2011). Ventricular tachycardia in the era of ventricular assist devices. *Journal of Cardiovascular Electrophysiology, 22*(3), 359-363. doi:10.1111/j.1540-8167.2010.01911.x

Chmielinski, A., & Koons, B. (2017). Nursing care for the patient with a left ventricular assist device. *Nursing2017, 47*(5), 34-40. Retrieved from www.Nursing2017.com

Cho, S. M., Moazami, N., & Frontera, J. A. (2017). Stroke and intracranial hemorrhage in HeartMate II and HeartWare left ventricular assist devices: A systematic review. *Neurocritical Care, 27*(1), 17-25. doi:10.1007/s12028-017-0386-7

Demirozu, Z. T., Radovancevic, R., Hochman, L. F., Gregoric, I. D., Letsou, G. V., Kar, B., …, Frazier, O. H. (2011). Arteriovenous malformation and gastrointestinal bleeding in patients with the HeartMate II left ventricular assist device. *The Journal of Heart and Lung Transplantation, 30*(8), 849-853. doi:10.1016/j.healun.2011.03.008

DeVore, A. D., Hammill, B. G., Sharma, P. P., Qualls, L. G., Mentz, R. J., Waltman Johnson, K., …, Hernandez, A. F. (2014). In-hospital worsening heart failure and associations with mortality, readmission, and healthcare utilization. *Journal of the American Heart Association, 3*(4). doi:10.1161/JAHA.114.001088

Eckman, P. M., & John, R. (2012). Bleeding and thrombosis in patients with continuous-flow ventricular assist devices. *Circulation, 125*(24), 3038-3047. doi:10.1161/CIRCULATIONAHA.111.040246

Gurvits, G. E., & Fradkov, E. (2017). Bleeding with the artificial heart: Gastrointestinal hemorrhage in CF-LVAD patients. *World Journal of Gastroenterology, 23*(22), 3945-3953. doi:10.3748/wjg.v23.i22.3945

Harvey, L., Holley, C. T., & John, R. (2014). Gastrointestinal bleed after left ventricular assist device implantation: Incidence, management, and prevention. *Annals of Cardiothoracic Surgery, 3*(5), 475-479. doi:10.3978/j.issn.2225-319X.2014.08.19

Heidenreich, P. A., Trogdon, J. G., Khavjou, O. A., Butler, J., Dracup, K., Ezekowitz, M. D., …, Woo, Y. J. (2011). Forecasting the future of cardiovascular disease in the United States: A policy statement from the American Heart Association. *Circulation, 123*(8), 933-944. doi:10.1161/CIR.0b013e31820a55f5

INTERMACS. (n.d.). Retrieved from https://www.uab.edu/medicine/intermacs/. Accessed October 14, 2018.

Jennings, D. L., & Weeks, P. A. (2015). Thrombosis in continuous-flow left ventricular assist devices: Pathophysiology, prevention, and pharmacologic management. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy, 35*(1), 79-98. doi:10.1002/phar.1501

Jessup, M., Abraham, W. T., Casey, D. E., Feldman, A. M., Francis, G. S., Ganiats, T. G., …, Yancy, C. W. (2009). 2009 focused update: ACCF/AHA guidelines for the diagnosis and management of heart failure in adults. *Journal of the American College of Cardiology, 53*(15), 1343-1382. doi:10.1016/j.jacc.2008.11.009

Liu, L. & Eisen, H. J. (2014). Epidemiology of heart failure and scope of the problem. *Cardiology Clinics, 32*(1), 1-8.

Mozaffarian, D., Benjamin, E. J., & Go, A. S., Arnett, D. K., Blaha, M. J., Cushman, M., …, Turner, M. B. (2016). Heart disease and stroke statistics—2016 update: A report from the American Heart Association. *Circulation, 133*(4), e38-e360.

Nicholson, J. D., & Kaakeh, Y. (2018). Pharmacotherapy considerations for long-term management of patients with left ventricular

assist devices. *American Journal of Health-System Pharmacy, 75*(11), 755-766. doi:10.2146/ajhp170317
Nienaber, J. J., Kusne, S., Riaz, T., Walker, R. C., Baddour, L. M., Wright, A. J., …, Sohail, M. R. (2013). Clinical manifestations and management of left ventricular assist device-associated infections. *Clinical Infectious Diseases, 57*(10), 1438-1448. doi:10.1093/cid/cit536
O'Shea, G., Teuteberg, J. J., & Severyn, D. A. (2013). Monitoring patients with continuous-flow ventricular assist devices outside of the intensive care unit: Novel challenges to bedside nursing. *Progress in Transplantation, 23*(1), 39-46. doi:10.7182/pit2013494
Parikh, N. S., Cool, J., Karas, M. G., Boehme, A. K., & Kamel, H. (2016). Stroke risk and mortality in patients with ventricular assist devices. *Stroke, 47*(11), 2702-2706. doi:10.1161/STROKEAHA.116.014049
Pedretti, S., Cipriani, M., Bonacina, E., Vargiu, S., Gil Ad, V., Frigerio, M., & Lunati, M. (2017). Refractory ventricular tachycardia caused by inflow cannula mechanical injury in a patient with left ventricular assist device: Catheter ablation and pathological findings. *Journal of Arrhythmia, 33*(5), 494-496. doi:10.1016/j.joa.2017.04.007
Raj, L., & Adhyaru, B. (2016). An evidence-based review of recent advances in therapy for heart failure with reduced ejection fraction (HFrEF). *Postgraduate Medical Journal, 92*(1094), 726-734. doi:10.1136/postgradmedj-2016-134378
Sajgalik, P., Grupper, A., Edwards, B. S., Kushwaha, S. S., Stulak, J. M., Joyce, D. L., …, Schirger, J. A. (2016). Current status of left ventricular assist device therapy. *Mayo Clinic Proceedings, 91*(7), 927-940. http://dx.doi.org/10.1016/j.mayocp.2016.05.002
Salomon, S., Frankel, H., Chuang, E., Eti, S., & Selwyn, P. (2018). Implementing routine palliative care consultation before LVAD implantation: A Single Center Experience. *Journal of Pain and Symptom Management, 55*(5), 1350-1355. doi:10.1016/j.jpainsymman.2017.12.490
Schaffer, J. M., Allen, J. G., Weiss, E. S., Arnaoutakis, G. J., Patel, N. D., Russell, S. D., …, Conte, J. V. (2011). Infectious complications after pulsatile-flow and continuous-flow left ventricular assist device implantation. *Journal of Heart and Lung Transplantation, 30*(2), 164-174.
Scientific Registry of Transplant Recipients. (n.d.). Retrieved from https://www.srtr.org/about-the-data/guide-to-key-transplant-program-metrics/txguidearticles/time-to-transplant/. Accessed October 14, 2018.
Sen, A., Larson, J. S., Kashani, K. B., Libricz, S. L., Patel, B. M., Guru, P. K., …, Farmer, J. C. (2016). Mechanical circulatory assist devices: A primer for critical care and emergency physicians. *Critical Care, 20*, 153. Retrieved from https://www.researchgate.net/publication/303482700_Mechanical_circulatory_assist_devices_A_primer_for_critical_care_and_emergency_physicians
Starrh, L., & Becker, D. (2018). Ventricular assist devices: The basics. *The Journal for Nurse Practitioners, 14*(7), 538-544.
Topkara, V. K., Kondareddy, S., Malik, F., Wang, I. W., Mann, D. L., Ewald, G. A., & Moazami, N. (2010). Infectious complications in patients with left ventricular assist device: Etiology and outcomes in the continuous-flow era. *The Annals of Thoracic Surgery, 90*(4), 1270-1277. doi:10.1016/j.athoracsur.2010.04.093
Turner, K. R. (2019). Right ventricular failure after left ventricular assist device placement: The beginning of the end or just another challenge? *Journal of Cardiothoracic Vascular Anesthesia, 33*(4), 1105-1121.
van Riet, E. E., Hoes, A. W., Limburg, A., Landman, M. A., van der Hoeven, H., & Rutten, F. H. (2014). Prevalence of unrecognized heart failure in older persons with shortness of breath on exertion. *European Journal of Heart Failure, 16*(7), 772-777. doi:10.1002/ejhf.110
Yancy, C. W., Jessup, M., Bozkurt, B., Butler, J., & Casey, D. E., Jr., Drazner, M. H., …, Wilkoff, B. L. (2013). 2013 ACCF/AHA guideline for the management of heart failure: A report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines. *Circulation, 128*(16), e240-e327.

For additional continuing education activities on home healthcare nursing topics, go to nursingcenter.com/ce.

Instructions for Taking the CE Test Online Chronic Heart Failure Treatment: With the Left Ventricular Assist Device

- Read the article. The test for this CE activity can be taken online at www.nursingcenter.com/ce/HHN. Tests can no longer be mailed or faxed.
- You will need to create a free login to your personal CE Planner account before taking online tests. Your planner will keep track of all your Lippincott Professional Development online CE activities for you.
- There is only one correct answer for each question. A passing score for this test is 14 correct answers. If you pass, you can print your certificate of earned contact hours and the answer key. If you fail, you have the option of taking the test again at no additional cost.
- For questions, contact Lippincott Professional Development: 1-800-787-8985.

Registration Deadline: June 4, 2021.

Disclosure Statement:

The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

Provider Accreditation:

Lippincott Professional Development will award 1.5 contact hours for this continuing nursing education activity.

Lippincott Professional Development is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation.

This activity is also provider approved by the California Board of Registered Nursing, Provider Number CEP 11749 for 1.5 contact hours. Lippincott Professional Development is also an approved provider of continuing nursing education by the District of Columbia, Georgia, and Florida CE Broker #50-1223.

Payment:

- The registration fee for this test is $17.95.