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Nursing care for the patient with a left ventricular assist device

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HEART FAILURE (HF) is a major public health issue associated with significant morbidity, mortality, and healthcare expenditures. Mechanical circulatory support devices (MCSDs) such as left ventricular assist devices (LVADs) provide an alternative to heart transplantation for patients with advanced HF. Nurses need to understand how to care for the specific needs of these patients. This article provides a brief overview of the different types of ventricular assist devices (VADs), the unique aspects of nursing care for patients with LVADs, and the most common reasons for hospital admission.

Growing need

HF is on the rise, affecting more than 5 million Americans due to the aging population and increasing rates of obesity and diabetes in the United States.[1] Initially, patients can manage their HF with lifestyle changes and medication, but as their clinical status worsens, more aggressive therapy is needed for survival. Heart transplantation continues to be the gold standard treatment for end-stage HF, but the lack of organ donations and the significant increase in the prevalence of HF means that not every patient can receive a heart transplant.

MCSDs are a promising alternative treatment to heart transplantation for patients with advanced HF. An LVAD is the most common type of MCSD. The number of patients receiving mechanical circulatory support (MCS), particularly LVADs, is expected to increase because of the increasing prevalence of HF and limited donor availability for transplant.[2]

The increasing use of LVADs means that nurses may see more patients in the inpatient and outpatient settings with medical or device-related problems. To care for these patients, nurses need to understand LVAD technology, the types of complications patients may have, and how to care for patients with an LVAD.

Role of devices

MCS has been an HF treatment option for the last few decades. Today, over 15,000 U.S. patients have an MCSD.[3] An MCSD such as an LVAD is a mechanical pump that's surgically implanted into the patient's chest to support heart function and blood flow. The three types of VADs are right ventricular assist device (RVAD), biventricular assist device (BIVAD), and LVAD. The

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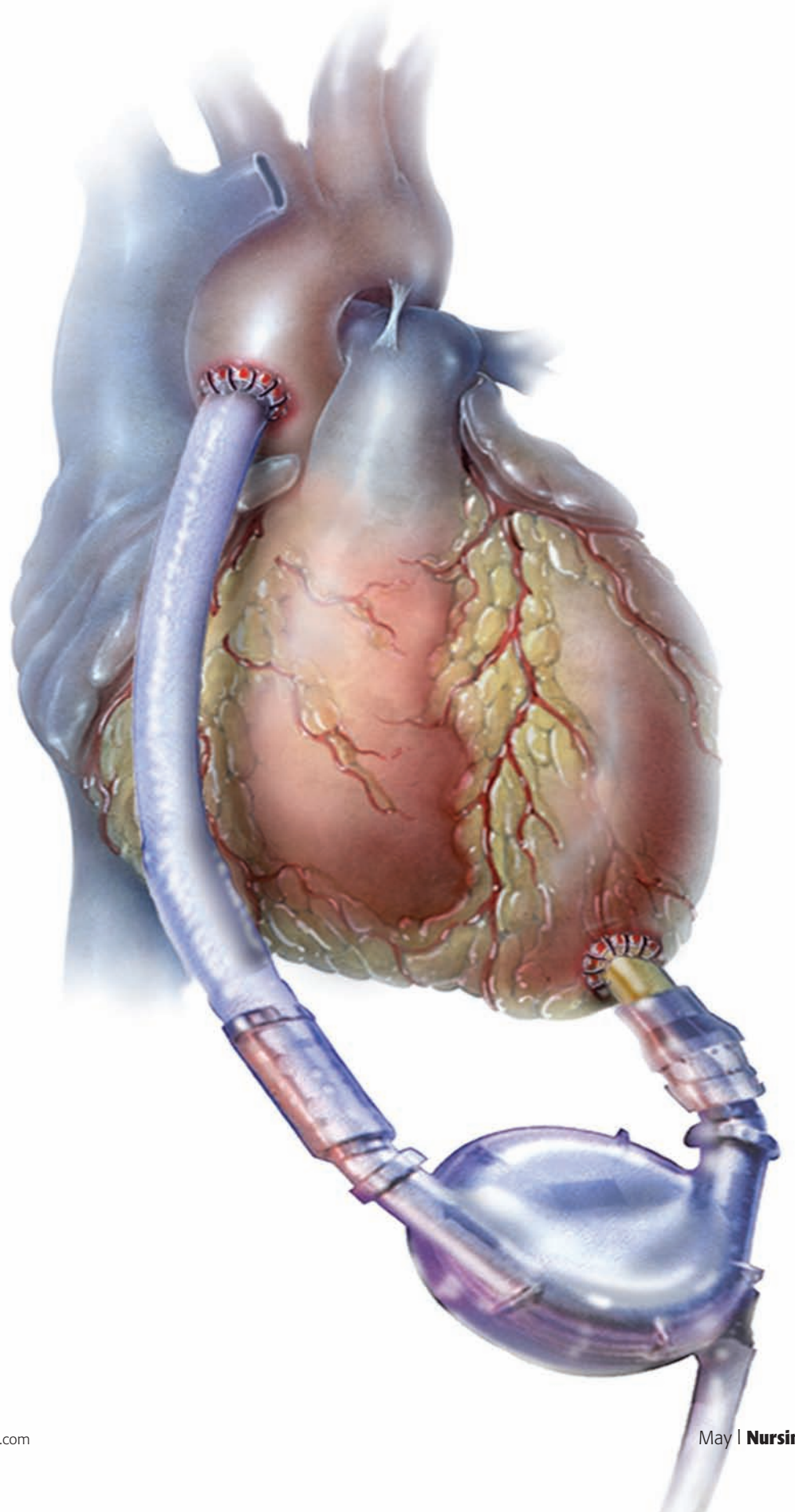
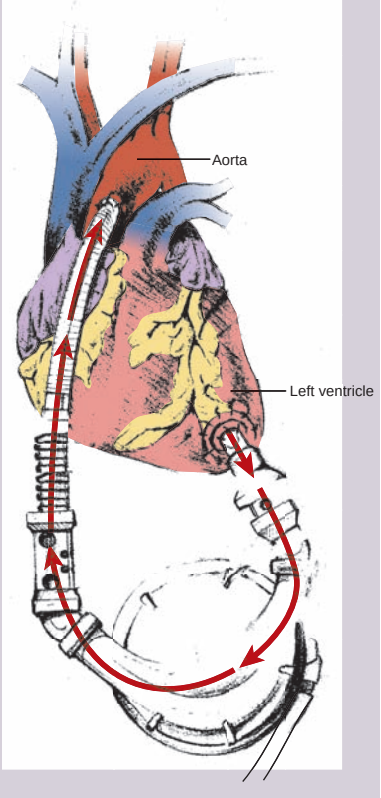


RVAD helps pump blood from the right ventricle to the pulmonary artery. The RVAD is used only for short-term purposes, and these patients must stay in the hospital. The BIVAD is used if both ventricles need support.[4]

The focus of this discussion, however, will be on the LVAD. The LVAD is the most common type of VAD; it works by unloading the left ventricle and pumping blood to the aorta. LVADs extend and improve the quality of life of patients who may have otherwise died while waiting for a heart transplant.[2] Patients with an LVAD can be discharged from the hospital and manage their device independently at home. However, follow-up care with the VAD team is needed. VAD teams are typically made up of cardiac surgeons, cardiologists, and VAD nurses who specialize in caring for these patients.

Anatomy of an LVAD



LVADs are used as a bridge to transplant, decision, recovery, or destination therapy. Patients identified as bridge to transplant are supported by the LVAD until a heart transplant becomes available. In some cases, patients receive an LVAD before a final decision related to transplantation eligibility has been reached (bridge to decision). The LVAD supports these patients until they become eligible candidates for transplant.[5]

If patients aren't eligible for transplant, their goals of care will change from bridge to transplant to destination therapy. Patients who need destination therapy are often not eligible for organ transplantation and use the LVAD as a permanent device.

LVADs can also be used as bridge to recovery. In this situation, the unloading of the heart that the LVAD provides can promote recovery of myocardial function to a level at which the LVAD can be removed.[2]

A closer look at an LVAD

An LVAD consists of an inflow and outflow cannula, a pump, a driveline, a system controller, and a power source. The inflow cannula is connected to the left ventricle and draws blood from the left ventricle into the pump. The outflow cannula carries blood from the pump to the ascending aorta, then blood is delivered to the rest of the body. The pump is located at the apex of the left ventricle.[2] (See *Anatomy of an LVAD*.)

The two types of pumps are pulsatile flow and continuous flow devices. The first-generation pulsatile flow devices move blood from the pumping chamber to the outflow cannula via forced air or electricity. Pulsatile pumps produce a pulse pressure that mimics the systole and diastole of native heart function. However, the use of pulsatile LVADs has become less common because of their large size, weight, and limited durability.[6]

Over the past few years, there's been a dramatic shift from the use of pulsatile flow to second-generation continuous flow devices. Continuous flow devices are designed to unload the heart throughout the cardiac cycle using a central rotor or impeller. The rotor continuously propels blood, providing continuous blood flow into systemic circulation. This may result in a weak, irregular, or nonpalpable pulse due to the continuous forward flow from the VAD. Continuous flow pumps are preferred because of their smaller size and durability, and because they provide a better quality of life and rate of survival.[1] In addition, continuous flow devices are quieter and their drivelines are smaller, resulting in lower rates of driveline infections.[7]

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.[8]

When caring for a patient with a nonpulsatile or continuous flow LVAD, nurses need to understand various LVAD functions including pump speed, flow, power, and pulsatility index (PI). The *pump speed* is a fixed number, set by the VAD team, which directly 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 (RPMs). The only parameter on the LVAD that can be adjusted is the RPMs, which are determined and adjusted by a member of the VAD team.[6]

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 (L/min).[6]

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. A gradual increase in power may signal thrombus inside the LVAD.[6]

The last key parameter of continuous flow LVADs is the PI. When the native left ventricle contracts, an increase in ventricular pressure causes an increase in pump flow during systole. The PI is the magnitude of change in flow through the LVAD during the cardiac cycle averaged over intervals of 15 seconds.[6] The PI is inversely related to the amount of assistance provided by the LVAD. A high PI indicates more native ventricular filling and less pump support. A lower PI value indicates less ventricular filling due to less circulating blood volume or an obstruction in the LVAD, meaning the patient requires more pump support. LVADs depend on adequate preload. A reduction in preload caused by dehydration, overdiuresis, bleeding, or right ventricular dysfunction all result in reduced left ventricular preload and can affect the pump flow and PI.[6]

Major complications

Patients with an LVAD may experience complications requiring hospital admission. The Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) was established in 2005 to collect data relevant to MCSDs. (See *INTERMACS levels.*) The 2014 INTERMACS report revealed that bleeding, infections, dysrhythmias, and strokes were the most frequent adverse events in the first 12 months after LVAD placement.[3] Nurses need to understand why patients with an LVAD are at risk for these complications and how to care for these patients if they're admitted to the hospital. The following sections review the causes of hospital admission for patients with an LVAD and nursing care for these patients.

• **Hypotension.** Patients with an LVAD can experience hypotension for a number of reasons, including infection, gastrointestinal bleeding, and dehydration. Continuous flow LVADs have a narrow pulse pressure, usually less than 15 mm Hg, resulting in diminished peripheral pulses that frequently can't be palpated. For this reason, standard noninvasive BP measurements are difficult to obtain, but BP measurements can be obtained with a Doppler or electronic noninvasive BP cuff.[6]

In the CCU, arterial lines are preferred to allow for closer monitoring of a patient's BP. Because continuous flow LVADs are nonpulsatile, patients with an LVAD won't have a normal arterial waveform. Instead, the arterial waveform will be dampened, but a systolic, diastolic, and mean arterial pressure (MAP) can still be obtained. MAPs should be maintained between 70 and 80 mm Hg and shouldn't exceed 90 mm Hg to ensure appropriate perfusion and to prevent retrograde flow.[6,9] Nurses also need to closely monitor the patient's PI, flows, and RPMs to assess the patient's fluid status and function of the LVAD.[9]

• **Infection.** A significant cause of morbidity and mortality in patients with an LVAD is infections. They're divided into three categories:[10]

– device-specific infections involve the pump, cannula, pocket, or percutaneous driveline

– device-related infections include infective endocarditis, bacteremia, and mediastinitis

– nondevice-related infections include urinary tract infections, respiratory tract infections, cholecystitis, and *Clostridium difficile* infection.

Driveline infections are the most frequent type of infection.[10] Nurses must minimize the risk of driveline infections by ensuring that the driveline is secured by an anchoring device. These devices are similar to ones used to secure indwelling urinary catheters. Sterile technique should always be used when performing LVAD site care.

Initially, the frequency of dressing changes is determined by the providers at the hospital who implanted the LVAD; dressing changes are usually done daily, then decrease in frequency to every other day or weekly. If a driveline infection is suspected, the dressing changes are increased to daily. If patients have erythema, purulent drainage, or a temperature above 100.4° F (38° C), they should notify their VAD center and go to the ED or nearest hospital as directed.[10]

Many VAD teams ask patients to take a photo of their driveline site and send it to their practitioners to evaluate and determine the severity of the infection. 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.[6]

• **Sepsis.** Managing patients with an LVAD and sepsis is similar to managing patients with sepsis who don't have an LVAD except that assessing changes in BP and fluid management are more challenging in patients with an LVAD. Treatment includes obtaining blood cultures, possibly culturing the LVAD driveline site, providing antibiotic therapy when indicated, and administering fluids to prevent hypovolemia. If the infection is

INTERMACS levels

Level 1: Critical cardiogenic shock
Level 2: Progressive decline despite inotropic support
Level 3: Stable but inotropic dependent
Level 4: Resting symptoms
Level 5: Exertion intolerant
Level 6: Exertion limited
Level 7: Advanced New York Heart Association (NYHA) Functional Classification III

Source: Ravichandran AK, Cowger J. Left ventricular assist device patient selection: do risk scores help? *J Thorac Dis.* 2015;7(12):2080-2087.

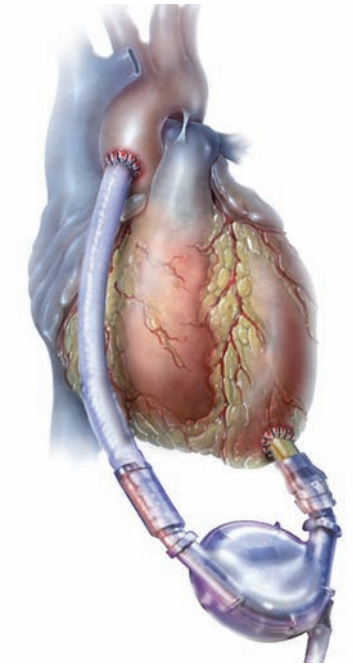
refractory to medical therapy, surgical intervention may be warranted. This may include debridement or, in some cases, removal of the device and placement of a new LVAD.[10]

Patients with recent bloodstream infections who complain of a headache or other neurologic symptoms may be experiencing a hemorrhagic stroke and should undergo urgent computed tomography (CT). Care for these patients should include frequent neurologic assessments.[11]

• **Gastrointestinal bleeding.** Another notable adverse event after implantation of a continuous flow LVAD is gastrointestinal bleeding (GIB). Researchers at the University of Texas Health Science Center showed that GIB occurs in about 24% of patients with continuous flow LVADs, with no difference in incidence in regard to device type, INTERMACS score, or blood type.[9] Patients with continuous flow devices are hypothesized to develop acquired von Willebrand disease due to increased shear stress of the rotating impeller of the LVAD and reduced pulsatility of the device.[9] In addition, patients with an LVAD are on multimodal anticoagulation to prevent thrombus formation, and this can predispose patients to bleeding. Many patients take warfarin, clopidogrel, or aspirin for thrombosis prophylaxis.

Patients may also be at risk for developing angiodysplasia. Up to one-third of patients with an LVAD have episodes of GIB due to angiodysplasia or arteriovenous malformations in the gastrointestinal tract.[12] Continuous flow LVADs are thought to cause a reduced pulse pressure, which can lead to intestinal hypoperfusion, causing regional hypoxia, vascular dilation, and development of angiodysplasia.[13]

Management of patients with GIB consists of reversing anticoagulation and treating hypovolemia with fluids and blood products. Anticoagulation



The increased use of LVADs means that nurses may see more patients with device-related problems.

can be reversed with fresh frozen plasma and vitamin K (phytonadione); in some urgent cases, warfarin reversal is needed and inactivated prothrombin complex concentrates (also known as factor IX complex) containing the vitamin K-dependent coagulation factors in the inactivated form may be administered.[12] Providers must weigh the severity of the GIB with the relative risk of fully reversing anticoagulation, which could lead to pump thrombosis and other thrombotic events, such as acute ischemic stroke.

Additional medications that might be used to treat GIB include octreotide, a somatostatin analogue, or desmopressin acetate.[9] Administer volume resuscitation with I.V. fluids and blood products to maintain MAP between 70 and 80 mm Hg. Monitor serial complete blood cell counts and consult a gastroenterologist as needed to evaluate the source of the bleeding.

• **Dysrhythmias.** Patients with an LVAD are at high risk for atrial and ventricular dysrhythmias. Alterations in cardiac rate and rhythm are sometimes poorly tolerated because right and left ventricular filling and function are compromised, which can lead to decompensated HF, syncope, and sometimes death. Management of atrial dysrhythmias in patients with an LVAD is similar to patients without an LVAD. For rate control, beta-blockers are preferred over calcium channel blockers because calcium channel blockers provide no functional or mortality benefit and may worsen outcomes.[14] If beta-blockers aren't well tolerated, amiodarone is preferred for atrial dysrhythmias.[15] To treat ventricular dysrhythmias, amiodarone, lidocaine, and dofetilide are often prescribed.[13]

The incidence of ventricular dysrhythmias among patients with an LVAD ranges from 22% to 52%.[15] Most patients with an LVAD have an implantable cardioverter-defibrillator (ICD). Nurses and providers must be aware of the settings of these devices and have them interrogated if dysrhythmias are suspected. The ICD may terminate the ventricular dysrhythmias with antitachycardia pacing or internal shocks.[15] If patients have received internal shocks, their anxiety needs to be treated because the catecholamine surge after receiving shocks predisposes them to more ventricular tachycardia episodes. Antiarrhythmic therapy is often used, with amiodarone being the most frequently used medication.

To assess how the patient tolerates dysrhythmias, the nurse should monitor LVAD parameters, especially the PI. Low PIs can lead to "suction events," which means the left ventricle is underfilled and is being "sucked" into the LVAD.

Administering fluid can help improve this temporarily, but a VAD coordinator or physician should be contacted. The VAD coordinator may want to decrease the RPMs, which will reduce the speed of the device and decrease the incidence of suction events.[6]

• **Neurologic events.** Patients with an LVAD are at increased risk for ischemic and hemorrhagic strokes. Head CT is needed to identify the type of 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.[16] Ischemic strokes occur in 8% to 10% of patients with an LVAD.[9,13] Patients' international normalized ratio should ideally be maintained between 1.5 and 2.5. Causes of hemorrhagic stroke in these patients include hemorrhagic transformation of an ischemic stroke, overanticoagulation, or infection.[16]

The primary goal is decreasing anticoagulation to limit ongoing bleeding. Anticipate administering I.V. vitamin K and fresh frozen plasma.[17] Monitor coagulation studies and assess neurologic function closely. The degree to which the anticoagulation is reversed depends on the severity of the cerebral hemorrhage; it should be balanced with the possibility of thromboembolic events with anticoagulation reversal.[2]

Critical alarms

Practitioners caring for patients with LVADs must understand the critical alarms and how to correct them. In the event of LVAD alarms, contact the VAD coordinators or physicians caring for the patient.

Hazard or critical alarms, the most important kind of alarms, will be the focus of this discussion. Critical alarms have three causes: pump failure, critically low battery, and controller failure.[18]

Bonus content

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Update: AHA BLS and ACLS guidelines
http://journals.lww.com/nursing/Fulltext/2016/02000/Update__2015_AHA_BLS_and_ACLS_guidelines.13.aspx.

In the case of *pump failure*, potential causes include driveline disconnection or fracture, 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. To correct *controller failure,* the controller must be changed. Patients should have a spare controller with them that's already programmed. The VAD coordinator should be contacted to assist with the controller exchange if assistance is required.[18]

CPR and advanced cardiovascular life support

Resuscitating patients with LVADs presents unique challenges. A few of these challenges include difficulty palpating the patient's pulse, malfunction of the device precipitating the event, and possible dislodgement of the device or the outflow cannula during CPR.

Follow the advanced cardiovascular life support guidelines when a patient with an LVAD is unresponsive, apneic, and pulseless, and be aware of potential complications of treatment such as internal bleeding following CPR.[13,19]

Suspect device malfunction when patients with an LVAD present in cardiac arrest. Call the VAD coordinators and assist the team with troubleshooting in these instances. The causes include loss of power to the controller, damage to the driveline, or terminal rhythms that cause a drop in flows and pulseless electrical activity.[19]

Some practitioners believe that CPR should be avoided because of the location of the LVAD and believe that CPR may dislodge components of the device, resulting in fatal bleeding.[17]

End-of-life issues

Healthcare providers should discuss end-of-life care for patients with an LVAD. Some patients with an LVAD may elect to have their device turned off because of life-limiting illness other than heart disease or due to complications with the device that have led to a poor quality of life.

When the patient or surrogate decides to deactivate the device, it isn't considered physician-assisted suicide; instead, it's considered allowing natural death to occur.[20] Gafford and colleagues outlined important steps that should be addressed during deactivation; they include what should be discussed during the family meeting and interdisciplinary preparation for deactivation at the bedside.[20]

Looking to the future

The incidence of HF is increasing and advanced therapies, including LVADs, are in high demand. The

number of patients undergoing LVAD implantation will continue to increase. More nurses will be responsible for caring for these patients. All nurses need to be prepared to care for patients with an MCSD. Nurses must have an understanding of VADs, the components of an LVAD, critical alarms, common indications for hospital admission, and how to manage patients with an LVAD experiencing a medical emergency. ■

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