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Complications in Patients With Ventricular Assist Devices

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Heart failure affects more than 5 million people in the United States. The treatments of this disease include medical therapy, heart transplantation, and the implantation of ventricular assist devices. These devices are used in patients who are no longer responsive to conservative medical treatment, who are not candidates for a heart transplantation (destination therapy), who are awaiting a heart transplantation (bridge to transplantation), and who have acute heart failure and whose myocardial function is expected to return to normal (bridge to recovery). Although this therapy improves the mortality and quality of life among patients with heart failure, the devices also carry risk of multiple complications. This article discusses the acute and long-term complications of ventricular assist devices.

Keywords: Complications of VADs, Heart failure, Ventricular assist device

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Heart failure is one of the leading causes of death and hospitalization in the United States. The incidence of this disease has been on the rise, and the number of patients diagnosed with heart failure has reached more than 5 million cases in this country. There are approximately 280,000 deaths annually from heart failure, and most of the diagnosed patients die within 8 years from diagnosis.[1] It is estimated that there are approximately 60,000 patients with end-stage heart failure who are no longer responsive to medical therapy and who may benefit from heart transplantation.[2] However, because of the limited availability of transplant organs, there are approximately 2,100 heart transplantations performed each year.[3] In this situation, the use of ventricular assist devices (VADs) became a valuable therapy option for a patient with end-stage heart failure condition.

Another group of patients that benefit from the VADs are those who experience postoperative ventricular dysfunction or those who suffer from postcardiotomy cardiogenic shock. Since these patients are not able to be weaned from the cardiac bypass machines, VADs provide a temporary circulatory support until their myocardium recovers.[4]

Currently, VADs are improved by the Food and Drug Administration for use as a bridge to heart transplantation for those who await the transplant organs, as a bridge to recovery when myocardial function is expected to return to normal, and as destination therapy for patients with end-stage heart failure who are not candidates for heart transplantation and who will remain on VAD for life.[4] The selection of the type of VAD depends on a patient's medical condition, body surface

area, and history, including previous surgeries to sternum and the required length of the support.[5]

This article provides an overview of VADs and will discuss their benefits and acute and long-term complications. The role of the critical care nurse in caring for a patient with VAD is presented, concerning the patient's treatment, prevention of complications, discharge, and education.

The first VAD was introduced in 1963. Since that time, many improvements in the devices have evolved. With time, VADs were modified, reduced in size, and offered a lighter source of power, allowing patients to ambulate and perform daily activities.[5]

Ventricular assist devices can be inserted in the right (RVAD), left (LVAD), or both ventricles of the heart (bi-VAD). The devices also vary in types of pumping mechanism and their location with regard to the patient. The pumping mechanism can be pulsatile when it operates with a blood chamber that is compressed either by air or electric motor. The pumping can also be nonpulsatile (continuous), with axial or centrifugal flow. Furthermore, VADs can be located outside a patient's body (paracorporeal or extracorporeal), or they can be implanted inside the patient's body (intracorporeal).[6]

All VADs have 3 basic components: cannula, blood pump, and source of power. The pumping unit is connected to the ventricle of the heart via the cannula. The pump sends the stroke volume to the body via the aorta (see Figure 1). The goal of the device is to assist diseased and failing ventricles in pumping blood, thus decreasing the mortality of the patient. Table 1 summarizes the functions of VAD therapy.

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The benefits of the VAD therapy are undisputable and were confirmed in the Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH) trial. The trial was a randomized controlled study that was conducted on 129 patients with irreversible heart failure who were ineligible for heart transplantation. Out of the 129 patients, 68 received the device, and the remaining 61 patients were treated medically. The 1-year survival for those who received the device was 52%, and for those who were treated medically, it was 25%. The 2-year survival rate was 23% versus 8%. The REMATCH trial

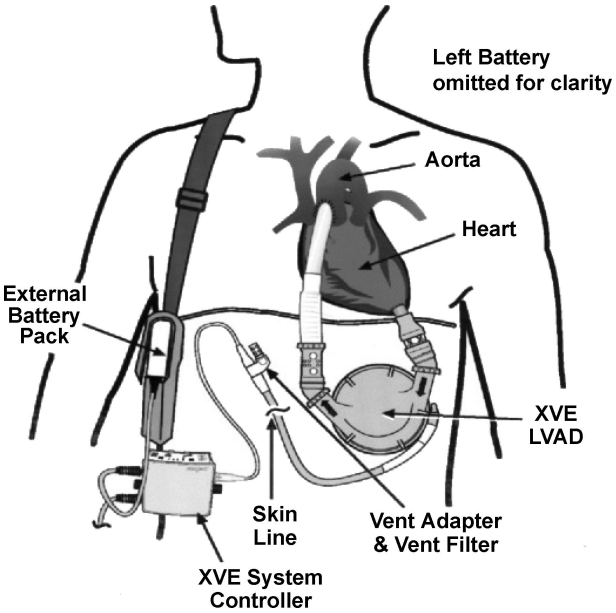

Figure 1. Long-term XVELVAS model HeartMate®.[4]

was aborted prematurely because of the remarkable benefits of VADs. Subsequently, this study led to the Food and Drug Administration's approval of the device for use as a destination therapy[7] in 2002.

ACUTE COMPLICATIONS

The development of the VADs opened the possibility for survival for many patients whose hearts are not able to function on their own. Ventricular assist devices improved the quality of life for patients with heart failure condition and gave them independence and a chance to return to normal functioning. However, despite the life-saving capabilities of the VADs, there are also negative consequences of their therapy. The devices pose risk of multiple complications that can be debilitating for patients and their families. They can also be very challenging for the critical care nurses who manage these patients. Many of the complications occur in acute care setting, shortly after the device implantation. Among these complications are altered immune response, thromboembolism, hemorrhage, right ventricular failure, and multisystem organ failure. However, some complications can also occur later, frequently after a patient is discharged home. The critical care nurse should assess and monitor patients with VADs in an effort to be proactive to decrease the incidence of complications.

Thromboembolism

Thromboembolism is one of the main concerns in patients with VADs. The reported incidence of thromboembolic

TABLE 1 Functions and Outcomes of Ventricular Assist Device Therapy

Functions of Ventricular Assist Therapy
Improve cardiac output and ejection fraction
Restore blood flow to body organs
Improve patient's hemodynamic status
Reduce cardiac workload
Reverse ventricular remodeling and hypertrophy
Decrease peripheral vascular resistance
Reverse pulmonary hypertension

events ranges from 10% to 25%.[2] The risk for the development of thromboembolism depends on the patient's condition such as presence of infection, the pump design, and the anticoagulation regimen used. Most thromboembolic events are cerebrovascular, but frequently, they are accompanied by other events such as peripheral embolization of the spleen, kidneys, extremities, or visceral arteries.[2] The REMATCH trial reports that 24% of patients with VAD experienced significant neurological events including stroke, transient ischemic attack, and toxic encephalopathy.[7]

The thromboembolic complications occur as a result of the contact between the foreign surface of the device and the patient's blood. The blood-foreign body interaction activates immune cells and coagulation pathways and attracts platelets and complement proteins, thus initiating the formation of a clot. Ventricular assist devices have irregular surfaces with multiple crevices, connections, and pockets that create low flow areas, which further promote clot formation.[8] All VAD types except the HeartMate® (Thoratec Corp, Inc., Pleasanton, CA, and Texas Heart Institute, Houston, TX) require antico agulation with warfarin and antiplatelet medications. Because the HeartMate® has a unique interior lining with a texture that promotes endothelial cells adherence and formation of biological intimal lining, this model requires only antiplatelet therapy.[9]

Adequate anticoagulation therapy is the single most effective measure that critical care nurses can take to prevent formation of thrombi.[2] Studies show that ineffective anticoagulation after implantation is the strongest risk factor for thromboembolic complications; up to 50% of embolic events may happen when activated partial thromboplastin time is below 60 seconds (normal is less than 33 seconds) and the international normalized ratio (INR)[2] is below 2.5. Another study confirms that maintaining the INR range between 2.5 and 3.5 is effective in preventing clot formation.[10] Other interventions used in prevention of thromboembolic complications are careful preoperative patient selection, limiting the device implantation in patients with significant neurological history, as well as revascularization of carotid arteries in patients with carotid stenosis.[8]

Hemorrhage

Postoperative bleeding is a frequent occurrence in patients with VAD. It occurs in 60% of patients with VAD[10] and approximately 20% to 40% of patients who undergo reoperation to treat hemorrhage.[11] Factors that contribute to postoperative bleeding include need for anticoagulation, prolonged surgical procedure with cardiopulmonary bypass, and extensive surgical dissection. Also, patients with heart failure condition are frequently prone to bleeding because they experience hepatic dysfunction because of hepatic congestion.[9]

Postoperative hemorrhage may contribute to further complications such as hypoperfusion, multiorgan failure, or intracranial bleeding. If a patient requires massive blood transfusion, there is further risk for respiratory failure that can lead to adult respiratory distress syndrome. Studies suggest that blood transfusions compromise the patient's immune system, which may lead to the development of infection. The patients with VAD who receive blood transfusions are also more likely to develop right ventricular failure. The transfusion causes distension of the right heart, which promotes the release of inflammatory cytokines. This can lead to pulmonary hypertension and ultimately result in right heart failure. Furthermore, blood transfusion elevates the reactive antibodies, which can interfere with the likelihood of future heart transplantation.[12]

These complications are life threatening and require the critical care nurse to work on reaching and maintaining homeostasis in patients with VAD. The VAD candidates need to be adequately evaluated and prepared before the surgery so that potential risk factors can be identified early, such as the use of medications and herbal products that can alter coagulation or platelet function, as well as history of previous bleeding episodes. Patients should be assessed for hepatomegaly, presence of jugular venous distension, and any bruises or petechiae. They should be also screened with regard to their nutritional status. Central venous pressure should be trended to determine the presence of venous congestion, right heart failure, and hepatic insufficiency. Detailed laboratory testing (coagulation and liver function studies) must be performed to detect any problems with coagulation. Postoperatively, critical care nurses have to observe patients closely for any signs that may indicate bleeding such as increased

output from chest tubes, tachycardia, tachypnea, decreased urine output, changes in mental status, diaphoresis, prolonged capillary refill, or dry mucous membranes. Patients who develop hemorrhage may have to return to the operating room, or they may be treated with blood product transfusions. It is recommended that the blood products such as packed red cells and platelets are leukoreduced, and the volume replacement solutions are warmed up to prevent hypothermia.[12]

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Immune Response

Ventricular assist devices are made of biomaterials that can trigger an inflammatory response and affect host immunity. When the VAD surface comes in contact with patient's blood, it promotes the activation of defective proliferation of T cells, which further leads to activation-induced cell death. This defect in T cell functioning may affect the patient's immunity, and it may make him/her more susceptible to further complications such as infections or thromboembolic events. Furthermore, the foreign surface of the devices can also induce B cell hyperreactivity and cause an autoimmune reaction. This can increase the risk of post-transplantation organ rejections in patients who eventually receive a heart transplant.[13]

Multiorgan Failure

Many of the patients with VAD undergo the implantation with already compromised end-organ function. Because of advanced heart disease, kidney and liver function may be deteriorated. Frequently, patients have been hospitalized for prolonged periods, their nutritional status is inadequate which may place them at further risk of organ damage. They may be already on mechanical ventilation and have pulmonary compromise. Prolonged surgery with cardiopulmonary bypass adds further stress on their bodies. All of these factors increase their risk for poor outcome after VAD transplantation. Many of patients with VAD do not recover after the device implantation and may develop multiorgan failure. Multiorgan failure is the major cause of death (34.8%) among patients with VAD.[14]

The multiorgan failure after the VAD implantation surgery has been explained by activation of inflammatory responses, release of cytokines and chemical mediators such as nitric oxide, endothelin, and prostaglandins that affect organ perfusion and cause organ damage.[15] The surgery itself is also a risk for infection, which may aggravate the inflammatory response. Furthermore, the changes in cardiac output, hemodilution, hypothermia, prolonged aortic clamping time, and massive blood transfusion add to the already reduced perfusion of end organs such as kidneys or liver.[15]

To minimize the organ failure that may follow VAD surgery, the implantation of the device should be optimally done before any signs of organ dysfunction. After the surgery, the nursing staff has to be thorough in monitoring any changes in patient's condition that may be a clue of impending organ failure. Accurate recording and interpretation of vital signs, physiological observations, and laboratory values can help to detect any problems and institute appropriate care in a timely fashion. For example, metabolic changes in patients may lead to the development of neurological symptoms that may present as a change in mental status, confusion, agitation, or seizures. If these are caught early on, the neurological damage can be reduced. The multiorgan failure can also cause immunosuppression; therefore, strict infection control is an important part of care for patients with VAD.[16]

Right Ventricle Failure

Patients with VADs are at risk for the development of the right heart failure (RHF), which is associated with a significant rise in mortality and morbidity of patients with VAD, higher rates of hemorrhage and kidney failure, and lower bridge to transplantation rates. Researchers estimate that RHF occurs in approximately 11% of patients after the insertion of the device.[14]

Many patients develop RHF suddenly after the LVAD insertion. Although some of them may have had some degree of right ventricular (RV) dysfunction before the surgery, the RV failure does not become apparent until after surgery when there is an obvious imbalance between newly supported left ventricle and failing right ventricle. The mechanical emptying of the left ventricle causes the intraventricular septum to bulge away from the right ventricle into left ventricle, thus reducing RV efficiency. Furthermore, the improved function of left ventricle causes higher forward flow of blood into systemic circulation. This increases venous return that may rise beyond capability of the right ventricle.[17] Other factors that contribute to decline of RV function after LVAD implantation include myocardial stunning, ischemia, arrhythmias, and increased pulmonary vascular resistance.[18]

The critical care nurse has to be watchful for any red flags of RHF. The signs that are concerning include a

rise in central venous pressure, decrease in device flow, empty left ventricle, and elevated pulmonary pressures. Affected patients require medical therapy with inotropes to help unloading of the right ventricle and pulmonary vasodilators such as nitric oxide. When medical therapy is ineffective, some of the patients may require insertion of right VAD. The temporary biventricular support is maintained until the recovery of right ventricle or until heart transplantation.[9]

LONG-TERM COMPLICATIONS

Some complications can occur later, frequently after the patient is discharged home. The long-term complications include infection, malnutrition, abdominal complications, device failure, and psychosocial problems. These complications are not isolated—they often overlap. Frequently, the development of one starts a cascade of problems, and other complications follow. Therefore, it is important that all healthcare providers have a good understanding of any possible complications, which can affect patients with VAD.

Infection

Infection is a frequent complication of VAD therapy and may be manifested by pneumonia, mediastinitis, urinary tract infections, or line sepsis. However, patients with VAD may also experience device-related chronic infections such as driveline infections, pump pocket infections, endocarditis, or sepsis.[9] The high rates of infections among patients with VAD may be related to the fact that the patients are already malnourished and weakened preoperatively and, therefore, more susceptible to pathogens.[19] The patients with VAD are also vulnerable to device-related infections because the device's percutaneous drivelines are exposed to outside pathogens. Furthermore, the devices have many cavities and pockets that harbor microorganisms. They create a turbulent blood flow through the pumps, which contributes to the adherence of the pathogens to device surfaces. The organisms that are most frequently responsible for VAD-related infections are *Staphylococcus* species, *Pseudomonas aeruginosa*, and *Candida*.[20] The risk factors for infection among the patients with VAD relate to patient comorbidities especially diabetes mellitus, obesity, and chronic obstructive pulmonary disease, as well as other factors such as length of the preoperative hospital stay, postoperative bleeding, blood transfusions, and the need for surgical re-exploration.[20]

There are multiple studies that report high rates of the device-related infections. The International Society for Heart and Lung Transplantation's Mechanical Circulatory Support Database reports 32.5% of device-related infections that lead to 7.9% mortality rate among VAD recipients.[14] The REMATCH trial revealed that there was a 28% probability of infection of the device within the first 3 months after the implantation.[9] Furthermore, 41% of patients who received VADs in this trial died of sepsis-related complications.[21] Another study that looked at 55 LVADs as bridge to transplantation reported that 53% of patients developed clinical infections (drivelines, urine, sputum, or abscess cavities within the device). Another retrospective study that was conducted on 90 patients with LVAD confirmed the high rate (20%) of device-related infections. The same study also demonstrated that the most common causative organism that was responsible for these infections was the *Staphylococcus* species.[22] Among the device-related infections, the most common are percutaneous driveline infections, and their rates range from 18 to 52%. The pocket infections are reported to occur between 11% and 31%. The infection in the VAD itself can reach up to 15%.[22]

The clinical presentation of driveline or pocket infections includes local signs and symptoms such as erythema, pain, induration, edema, warmth, and purulence at the subcutaneous tissues surrounding the device and at the cutaneous device exit site. Most of the driveline infections remain localized and are successfully treated with appropriate wound care and antibiotic treatment. The pocket infections are managed through debriment procedures, open drainage, and irrigation and moving the driveline to a clean exit site. In cases of device infections, the patients receive systemic antibiotic treatments until a heart transplantation can be performed or a new device can be implanted.[23]

The device-related infections increase the occurrence of thromboembolic events, strokes, and other complications; they prolong patient hospitalization and increase healthcare costs. They can also have devastating effects on patient's quality of life and family functioning.[22]

With the high infection rates, critical care nurses are faced with a variety of tasks when caring for these patients. Preoperatively, the patients with VAD have to be closely screened for any factors that may put them at risk for infection such as immunosuppression or poor nutritional status. While in the operating room, staff members have to closely follow specific procedures during patient preparation and device handling. During the immediate postoperative period, the patient's body is rewarmed and oxygenation needs are maintained. A sterile technique during dressing changes must be maintained. The percutaneous drivelines should be appropriately immobilized to ensure the healing process and tissue ingrowth to form a barrier to outside pathogens. Nurses are also cautioned about signs and symptoms of infection and any other factors that can place patients at

risk for poor wound healing. These include inadequate nutritional intake, mechanical stress on the wound, poor vascular supply, anemia, or a decreased albumin level. Patients should be extubated and mobilized as early as possible, and their central lines are removed as soon as their clinical condition permits.[9,22,24]

Abdominal Complications

Abdominal placement of VAD hardware places patients at risk for the development of serious abdominal complications. Constantini and collegues[25] conducted a study to identify VAD-associated abdominal complications and found that abdominal complications occur in 11% of VAD recipients. The most common complication is hardware infection, which the critical care nurse may identify by fever, increased fatigue, increased abdominal girth, anorexia, nausea, vomiting, and abnormal laboratory values. Most of these infections have a nosocomial source and are treated with aggressive antimicrobial therapy.[25]

A small abdominal cavity in patients with VAD may predispose them to fistula formation, gastrointestinal hemorrhage, and bowel obstruction as the hardware may adhere to the intestines. Patients may also experience different forms of abdominal herniation. Incisional hernia develops, as the tissue tensile strength is reduced around the healing site, and the intraabdominal pressure increases because of the device placement. Increased intraabdominal pressure along with a patient's increased activity and weight lifting (such as the devices and batteries) also causes inguinal hernias.[25] Diaphragmatic hernias are reported in 16% of patients, and they are likely to develop after the VAD is removed and heart transplantation is complete. Herniation of abdominal organs such as small and large intestines, stomach, or spleen into the thoracic cavity can lead to serious complications. Other serious abdominal problems reported in literature include cholecystitis, pancreatitis, gastric ulceration, and perforation. Therefore, critical care nurses and all healthcare providers must be vigilant to assess for signs and symptoms of abdominal problems (such as nausea, vomiting, and/or changes in bowel habits) so that they could be diagnosed as early as possible. The diagnostic tools used to evaluate abdominal complications include x-ray, computed tomography scan, and upper gastrointestinal study.[26,27]

Device Malfunction

Despite many modifications in the pump design, device malfunction continues to be a significant cause of mortality and morbidity. Left VAD failure was the second leading cause of death in the REMATCH trial.[7] Researchers report that 35% of patients experienced device failure during the 24 months after implantation. Of these, 52% involved the external components such as controller, batteries, or the Y-connector, and 48% involved the internal parts such as pump itself or inflow or outflow conduit. The device had to be replaced in 15% of patients.[28] Other studies report 17% of device malfunction during the first year of implantation.[29] Mechanical failures occur because of the wear and tear on the parts of the device. Their number increases with the length of device use, which can be quite lengthy for some patient. With time, the motor fails, the bearings and valves wear out, and the external components break down.[9]

Device malfunction becomes a problem in the management of patients with VAD, especially those with destination therapy. Therefore, it is important that the nursing and medical providers understand the troubleshooting methods and know how to diagnose the most common reasons for device dysfunction. Patients should be carefully assessed for any signs and symptoms of heart failure and any indications of device breakdown. Myers and associates[29] suggest that patients should be assessed monthly in outpatient clinics to auscultate heart sounds to determine any changes in pump sounds. The motor waveforms should be recorded and compared on regular bases. The records should be stored so that their analysis can be performed when alarms are signaled or other problems are detected. The analysis of waveforms can detect increased requirements for the power that may be a sign of excessive wear or resistance to pump output. One of the most helpful methods to determine the condition of VAD motor life is motor dust analysis. A technician collects a dust sample from the device vent, which is further analyzed for metal components. Higher concentration of certain components in dust is indicative of the deterioration of correlating parts of the motor. Patients who experience signs of device dysfunction or who are symptomatic of heart failure undergo transthoracic or transesophageal echocardiogram and possibly cardiac catherization. These diagnostic tests can determine any changes in the VAD valve functioning.[29]

Patient education is one of the most important aspects of the device maintenance. Patients should be educated with regard to the alarms and how to respond to emergencies such as manual device pumping in case of device failure. Education about the device maintenance and preparation with regard to the emergencies reduces the poor patient outcomes as a result of the device malfunction.

Malnutrition

Patients with VAD are confronted with many device-related issues that may disturb their nutritional status.

They are frequently already malnourished as a result of long-term effects of heart failure. Cardiac cachexia is the body's inflammatory and metabolic response that leads to malnutrition, muscle wasting, and weight loss in 50% of patients with heart failure condition.[30] There are multiple pathophysiological explanations of cardiac cachexia, which include reduced blood flow to tissues; cellular hypoxia; neurohormonal and immune activation; and altered protein, fat, and minerals metabolism.[31] Weight loss causes reduction in immune status and leads to increased mortality and morbidity.

The placement of the VAD further increases the patient's risk for nutritional deficits. As the device causes a chronic inflammatory state, the metabolic needs of the body are increased.[28] Patients with VAD are also known to experience anorexia, delayed gastric emptying, nausea, and vomiting. Physical and emotional stress related to the surgery causes an increase in gastric acid secretion resulting in indigestion. These factors affect the patient's nutritional status and compromise patient outcomes. The critical care nurse should collaborate with a dietician to meet the nutritional needs of these patients. Therefore, it is important that patients with VAD are assessed in detail with regard to their nutritional status and that they receive appropriate nutrition support.[30]

Nurses and other healthcare providers should complete a nutritional assessment and support to optimize the outcome for patients with VAD. They should also take steps in the assessment, prevention, and management of complications that relate to alteration in the nutritional status. These include assessing (1) prealbumin, (2) weight, (3) albumin, and (4) hematocrit and hemoglobin. Early ambulation and physical activity will help delayed gastric emptying to avoid the development of paralytic ileus. Enteral nutrition instead of intravenous support is encouraged as the optimal way of providing nourishment.

Psychosocial Issues

Studies show that most patients with VAD report improvement in physical functioning and well-being. However, there are certain aspects of patients' quality of life that remain problematic. Patients and their caregivers frequently express their concerns and anxiety with regard to physical limitations and complications that may result from the device. Patients report worries about infection, device failure, or malfunction and a risk of stroke. They also describe difficulties with sleeping, pain at the implantation site, disturbance with noise, and difficulties with physical activities. Studies further show that psychological issues with VADs impact not only the lives of their recipients but also those of their families and caregivers. Caregivers describe similar anxieties and worries as the patients with VAD.[32]

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To help patients and their families to best adapt to life with VADs and to alleviate their worries, healthcare professionals design specific discharge planning and educational programs that prepare the patients and their significant others as to how to deal with VAD issues.

The preparation process requires that the patients and their families attend classes where they are educated on how to operate the device. They are instructed how to change the power source from the battery to power base unit, how to interpret and respond to the alarms, and how to provide care in case of emergency such as the loss of electrical power. Furthermore, they are taught about all the necessary safety precautions like avoidance of immersion in water, avoidance of static electricity, and prevention of water getting into vent filter. Any of these dangers may result in device failure and the need for its replacement. Patients are shown how to wash and shower without jeopardizing the device or causing harm to themselves, how to travel, and how to perform driveline dressing changes. When patients receive a VAD for destination therapy, the preparation also includes specific steps that will prepare the patient for functioning in the community. This consists of an inspection of patient's home, checking of any electrical hazards, and the identification of nearby hospitals or fire stations that have backup generators in case of power outage.[4] Furthermore, the patients are also instructed on how to perform home tests daily such as taking blood pressure, temperature, and VAD flows. In some cases, they are educated how to measure the INR and how to take the anticoagulation medications accordingly.[33] Before the patients are discharged, they obtain appropriate referrals for outpatient counseling, physical therapy, dietary follow-up, future appointments, emergency contacts, and communication with the coordinator. A home healthcare agency is contacted so that home care nurses can visit with the patient, check on the incision site, and help with the dressing changes. Table 2 summarizes the main points of patient education.

Patient education and preparation are a part of specific multidisciplinary patient care protocols and an extensive discharge process. Many of the discharge steps are actually initiated during the early admission to ensure enough time for teaching and reinforcement of

TABLE 2 Summary of Patient Education[34]

Teaching Objectives for Ventricular Assist Patients
Understanding of activity limitations
Demonstration of proper wound care
Demonstration of accurately taking vital signs
Understanding of follow-up care and emergency contacts
Knowledge of parts of ventricular assist system, their operation, and maintenance
Understanding of device alarms

the education material. These include teaching with regard to self-care, medications (such as antiplatelet agents or antibiotics), and safety issues. Furthermore, the discharge includes a detailed assessment of the patient's support system, as the caregivers have a crucial role in the recovery and long-term outcome. Through the assessment, critical care nurses are able to identify unique areas of concern for the patient and individual interventions that will help to improve the quality of life. These include patient's ability for psychosocial adaptation to the new conditions and life situation and patient's mental health, social functioning, and life expectations. Each of these concerns is addressed on an individual level so that the patient is prepared on how to deal with the device. Any worries and fears are also addressed ahead of time through support groups, counseling, and training programs. This way, patients are able to gain confidence and reassurance with regard to the device.[33]

Complications from VAD therapy can pose many challenges for the healthcare providers, and they can be overwhelming for the patients and their families. During the initial period after the device implantation, the patients are managed in intensive care units. At that time, they are frequently supported by mechanical ventilation and pharmacologically sedated. Therefore, in the initial phase, the VAD complications are managed by medical providers without active patient involvement. However, after the patients recover, move from intensive care units, and, in many cases, are discharged from the hospital, the prevention and management of complications become part of their lives. This can be very challenging and stressful not only for the patients but also for their families or caregivers. Therefore, the patients need to be adequately prepared on how to deal with any possible future problems.

The patient's preparation is a multidisciplinary process that involves the cardiothoracic surgeon, cardiologist, critical care nurse, physical therapist, dietician, and social worker. This team approach ensures adequate patient management while he/she is an inpatient and appropriate patient preparation and follow-up after discharge from the hospital. In that process, the advanced practice nurses (APN) have an important role. The APNs may act as VAD program coordinators who bring together and manage all services involved. The APNs can also provide the teaching to the patient, family, and nursing staff. They make sure that the family is involved in the education and discharge and that they have good understanding of what to expect after the patient goes home. Furthermore, the APNs are involved in the patient's plan of care to make sure that progress is being made. They also act as clinicians by performing detailed assessment and implementation of appropriate care. This way, the APNs are able to use the various aspects of the advanced practice role while working with patients with VAD.

Ventricular assist devices are an important option in the management of patients with heart failure condition. They provide life-saving temporary treatment for patients awaiting heart transplantation or heart recovery, and they significantly improve mortality among patients who are ineligible for heart transplantation. However, VAD therapy poses significant risks for complications that may disturb the course of treatment and compromise patient's health. Critical care nurses work to implement protocols that will allow optimal patient functioning with the device. These steps, along with careful patient selection for the device and skillful patient management after the implantation surgery, can minimize the complications and improve patient outcome.

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