Ventricular Assist Device Implantation: Perioperative Nursing Considerations 3.5 CE

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Purpose/Goal

To provide the learner with knowledge specific to ventricular assist device (VAD) implantation.

Objectives

1. Discuss cardiomyopathy.
2. Describe mechanical circulatory support.
3. Identify the complications related to VAD implantation.
4. Describe the nursing care of patients undergoing VAD implantation.

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ABSTRACT

Treatment for patients in end-stage heart failure has been revolutionized by the development of the ventricular assist device (VAD), an implantable heart pump used for long-term mechanical circulatory support. These devices are now small, lightweight, and efficient continuous-flow pumps that have replaced the larger, heavier, fill-to-empty predecessors. Management of the VAD case requires interdisciplinary effort across a diverse continuum of care and an understanding of new implantation techniques. This article describes current advances in VAD technology, indications for use, and perioperative nursing considerations related to patients who have undergone VAD implantation.
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Key words: *cardiomyopathy, heart failure, LVAD, ventricular assist device, VAD.*

Heart failure, or cardiomyopathy (CMP), is a disease that affects approximately 5.1 million patients in the United States and millions more worldwide.[1] The American Heart Association defines CMP as "a serious disease in which the heart muscle becomes inflamed and weakened."[2] Cardiomyopathy is further defined as myocardial disease related to mechanical or electrical dysfunction that causes ventricular dilation.[3] Cardiomyopathy may be primary (ie, it occurs in the absence of other cardiac conditions) or secondary (ie, it occurs as a result of a medical condition), and it is classified into four basic categories:

- dilated CMP,
- hypertrophic CMP,
- restrictive CMP, and
- arrhythmogenic right ventricular CMP/dysplasia.[2]

Dilated CMP is the most common type and comprises 60% of all cardiomyopathies. Dilated CMP is characterized by a dilated left ventricle and impaired systolic function.[3] Although viral infections, coronary artery disease, or disorders involving other organs may be to blame, CMP is often idiopathic, with no identifiable underlying cause.[3] As the disease progresses, it may lead to end-stage heart failure, arrhythmias, and heart-valve problems.[3]

Physicians commonly treat heart failure using beta-blockers, angiotensin-converting enzyme (ACE) inhibitors, and diuretic therapy. Additionally, patients with CMP may require an implantable cardioverter defibrillator and biventricular pacemaker to control the risk of lethal cardiac arrhythmias, including atrioventricular (AV) block, symptomatic bradycardia, atrial fibrillation, and ventricular tachycardia.[3] Although medical management remains the first line of therapy for heart failure, surgical intervention using mechanical circulatory support becomes necessary when the extent of the failure progresses beyond pharmacotherapy treatment options.[4] Mechanical circulatory support is used to sustain and improve quality of life.[4-7]

MECHANICAL CIRCULATORY SUPPORT

For decades, surgeons have performed successful heart transplantations for patients with end-stage myocardial disease. The

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registry of the International Society for Heart and Lung Transplantation projects 85% one-year and 70% to 75% five-year survival rates for patients who have received cardiac transplants.[5] The demand for acceptable donor organs, however, far exceeds their availability, reducing access to this treatment.[4,7,8] Additionally, comorbidities such as morbid obesity and smoking often preclude patients with end-stage heart failure from transplantation candidacy.[7,9] These factors contribute to a rising number of patients requiring mechanical circulatory support (ie, ventricular assist device [VAD] implantation) as their health declines.[7,10]

Ventricular Assist Devices

Ventricular assist device implantation is indicated for patients with acute and chronic end-stage heart failure who have additional, significant, related organ failure (such as kidney and liver failure) that has proven refractory to all medical and surgical intervention.[4,5,11] Therapy goals vary based on the patient's clinical status and are categorized as either a bridge to transplantation (ie, sustain life until a transplant can be found) or destination (ie, the only therapy available to this patient). Subcategories include bridge to decision and bridge to recovery (Table 1).[2,5,9]

Our center treats patients who require a bridge to transplantation and those for whom VAD implantation (ie, destination therapy) is the only modality available, using institution-specific protocol guidelines to assess preoperative eligibility. These guidelines and assessments help ensure seamless and effective preoperative, intraoperative, and postoperative care.[11] Caring for patients who require VAD implantation is a collaborative, multidisciplinary effort requiring meticulous attention to detail and reliable, accurate communication between clinicians. The decision to implant a VAD does not depend on the type of CMP and is governed by the severity of disease as determined by a set of stringent guidelines.[11]

General criteria established by the Centers for Medicare & Medicaid Services guide the prescreening process for advanced heart-failure therapies, which is conducted by a team of medical professionals, including personnel from physical medicine and rehabilitation, social services, dietetics, and palliative care. After the provider completes the initial consultations, he or she presents the candidate to a VAD selection conference, in which team members from cardiology and cardiac surgery collaborate weekly with personnel from all involved services to decide on appropriate therapy.[11] To be eligible for VAD implantation, the patient must meet one of the following criteria:

- failure to respond to medical management for at least 45 of the preceding 60 days,
- dependence on a balloon pump for seven days, or
- dependence on IV inotropes for 14 days.

Additionally, the candidate must have a left ventricular ejection fraction of less than 25% and have demonstrated functional limitation with peak oxygen consumption of less than 14 mL/kg/min unless he or she is dependent on a balloon pump or inotropes.[11] Contraindications to VAD implantation include

- high-surgical-risk candidates;
- the presence of irreversible neurological dysfunction, stroke, or coexisting terminal illness;
- severe comorbidities; and
- the lack of a viable social support system.[11]

Advances in VAD Technology

In 1966, Michael DeBakey, MD, used a temporary device to maintain circulatory support for a patient with end-stage heart failure, by implanting the first left ventricular assist device (LVAD) after cardiac surgery.[7] This milestone was closely followed by the first human heart transplantation in 1967.[7] Subsequent VAD technology rapidly evolved from the temporary total artificial heart first used in 1969, to the Jarvik-7 total artificial heart first used in 1982, to the Novacor LVAD first used in 1984.[7] Although the promise of these devices generated hope, each demonstrated extensive shortfalls that presented unique challenges to pioneer surgeons and engineers. Although the approval of the immunosuppressant medication cyclosporine by the US Food and Drug Administration (FDA) in 1983 made cardiac transplantation more successful,[7] the need for a device to successfully support or "bridge" a patient until an acceptable donor could be found necessitated the further development of the LVAD technology.[5,7,9,10] Additionally, mounting evidence suggested that VADs could significantly improve and extend the lives of those ineligible for heart transplantation.[4,5,8,9]

Whereas scientists developed previous VAD models as a bridge to transplantation, the FDA approved pulsatile LVAD as destination therapy in 2003, after the Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH)[2] trial showed it significantly increased survival rates in patients with heart failure, compared with those of traditional pharmacotherapy.[5,7] The Centers for Medicare & Medicaid Services approved the device for full coverage in the same year.[5] This

Table 1. Cardiomyopathy-Related Terms and Definitions[1]

Term	Explanation
Arrhythmogenic right ventricular cardiomyopathy/dysplasia	A rare type of cardiomyopathy that occurs if the muscle tissue in the right ventricle dies and is replaced with scar tissue.
Bridge to transplantation	A mechanical device (eg, ventricular assist device [VAD]) that is used until an acceptable organ can be obtained.
Bridge to recovery	A mechanical device (eg, VAD) that is used until the heart muscle returns to adequate self-supporting circulation.
Cardiomyopathy	Diseases of the heart muscle that have many causes, signs and symptoms, and treatments.
Destination therapy	A mechanical device (eg, VAD) that is used for the duration of the person's life because of ineligibility for a heart transplantation (ie, no social support or intent to meet body mass index requirements). Patients selected for destination therapy usually have contraindications for heart transplantation, such as age greater than 70 years, malignancy in the past five years, or comorbidities including • insulin-dependent diabetes mellitus with end-organ damage, • chronic renal failure, • drug abuse, • severe obesity, or • fixed pulmonary hypertension with a transpulmonary gradient of above 15 mm Hg and vascular resistance of more than 6 Wood units.
Dilated cardiomyopathy	A disease in which the heart muscle begins to dilate, causing the inside of the chamber to enlarge. Dilated cardiomyopathy often begins in the left ventricle, the heart's main pumping chamber, and spreads to the right ventricle and then to the atria as the disease worsens.
Hypertrophic cardiomyopathy	Hypertrophic cardiomyopathy occurs if heart-muscle cells enlarge and cause the walls of the ventricles (usually the left ventricle) to thicken. Despite this thickening, the ventricle size often remains normal; however, the thickening may block blood flow out of the ventricle. If this happens, the condition is called *obstructive hypertrophic cardiomyopathy*.
Implantable cardioverter defibrillator	A battery-powered device placed under the skin that monitors heart rate and is capable of pacing the heart in cases of slow rhythms and providing defibrillation to correct abnormal, lethal arrhythmias.
Mechanical circulatory support	The use of mechanical devices to sustain circulation when medical treatment no longer is effective.
Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH) trial[2]	A 2001 landmark trial that demonstrated that implantation of left ventricular assist devices as destination therapy can provide better survival compared with that of any other known medical treatment in patients with end-stage heart failure who were ineligible for transplantation.
Restrictive cardiomyopathy	A disease in which the ventricles become rigid because abnormal tissue (eg, scar tissue) replaces the normal heart muscle. It mostly affects older adults.
VAD	A battery-operated, mechanical, pump-type device that is surgically implanted to help maintain the pumping ability of a heart that cannot effectively function on its own.

1. *American Heart Association. Conditions. 2015;* http://www.heart.org/HEARTORG/Conditions/The-Heart-and-Stroke-Encyclopedia_UCM_445688_SubHomePage.jsp. *Accessed December 2, 2015.*
2. *Hunt SA, Rose EA, for the Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH) Study Group. The REMATCH TRIAL: Long-term use of a left ventricular assist device for end-stage heart failure.* J Card Failure. *2002;8(2):59-60.*

pulsatile LVAD was, however, prone to wear and mechanical failure.

The subsequent development of continuous, nonpulsatile-blood-flow VADs initiated groundbreaking clinical trials using smaller, more advanced devices with longer durability and decreased rates of adverse events.[4-7,10,12] Continuous-flow VADs are associated with a decreased frequency of stroke, reduced adverse events and repeat hospitalizations, and an improved quality of the activities of daily living.[4,13] A dynamic, decades-long development process has resulted in the current use of two types of continuous-flow, nonpulsatile devices: the HeartMate II LVAD as bridge-to-transplantation and destination therapy and the HeartWare HVAD for bridge-to-transplantation indications only.[1,5,6,10,13]

Continuous-Flow Devices

The HeartMate II system (Figure 1) is an intracorporeal, axial, continuous-flow pump driven by a rotating impeller, resulting in a blood flow of 8 to 10 L/min. The pump weighs 300 g and generally connects the apex of the left ventricle with the ascending aorta through a woven vascular graft.[5] The device is considerably quieter than its pulsatile predecessors and has fewer moving parts.[5] The FDA approved the HeartMate II for bridge-to-transplantation therapy in 2008 and approved it for destination therapy in January 2010. More than 14,000 implantations have taken place worldwide.[5,6,10]

The HeartWare HVAD is an example of a newer-generation support device that uses a magnetic, levitating centrifugal system to propel blood up to 10 L/min. The pump is small and relatively compact, allowing the surgeon to insert the tip of the device directly into the left ventricular apex and house the entirety of the pump in the pericardium. This negates the necessity for dissecting an additional abdominal pocket space and minimizes concerns surrounding previous or future abdominal surgeries.[5,10,14] The surgeon affixes the outflow graft to the pump and anastomoses it end-to-side to the ascending aorta.[5,10] While the destination therapy ENDURANCE trial is underway, the FDA has approved the HeartWare HVAD device exclusively for

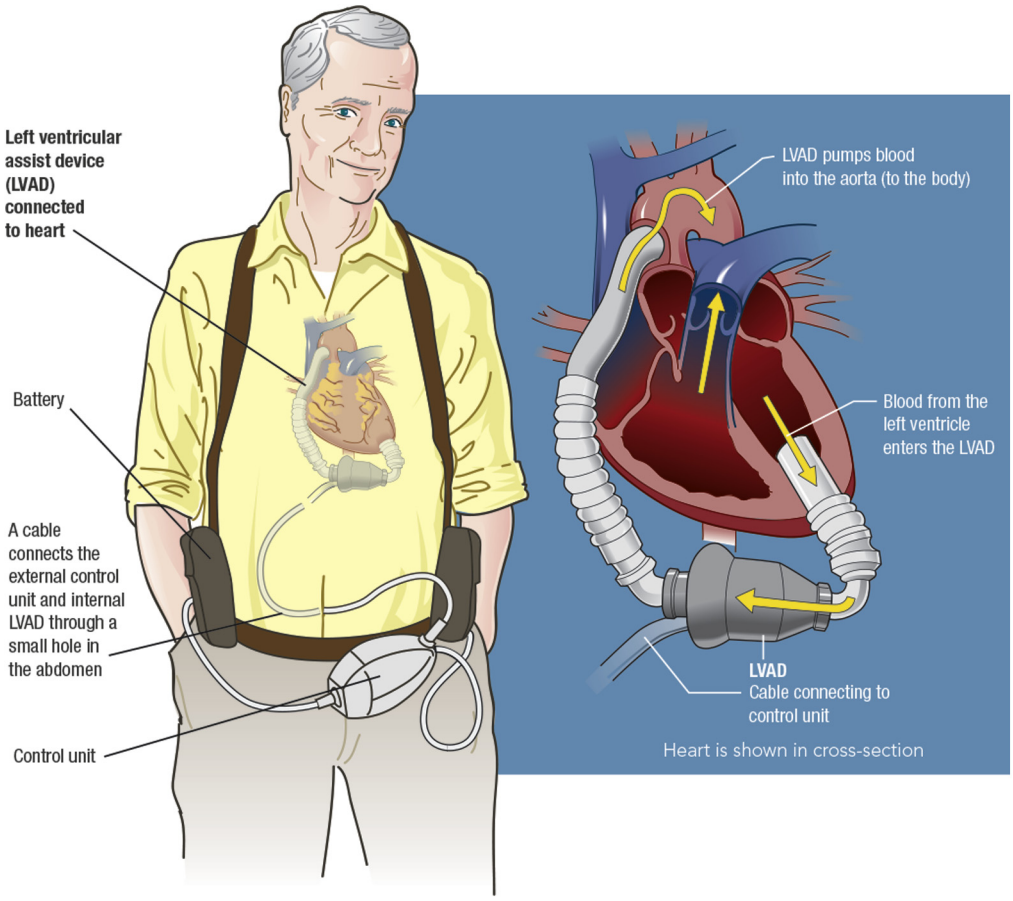

Figure 1. The HeartMate II system is an intracorporeal, axial, continuous-flow pump driven by a rotating impeller, resulting in a blood flow of 8 to 10 L/min. *Illustration by Kurt Jones.*

bridge-to-transplantation candidates, and surgeons have implanted more than 2,500 worldwide.[5,6,10,14]

The compact design of the HeartWare system allows the surgeon to use sternal-sparing and off-pump techniques for complex heart failure patients, including left thoracotomy with upper hemisternotomy and left thoracotomy with subclavian incision.[10,14-16] These approaches were designed to reduce cardiopulmonary bypass and procedure time, with the intent of minimizing blood loss and avoiding the need for multiple sternotomies. Informal internal studies conducted at our center suggest that minimally invasive implantation may provide right ventricular protection; because the pericardium is not compromised as it is in a standard sternal approach, the geometric integrity of the right ventricle is maintained.[10,15,16] Both systems cost the implanting institution more than $100,000 for the implants and related devices. Multicenter clinical trials are currently underway to evaluate the use of the HeartMate III Left Ventricular Assist System in patients with advanced-stage heart failure,[17] and trials for HeartWare Miniature Ventricular Assist Device pump are forthcoming.

VAD IMPLANTATION

The implantation procedures for both devices are relatively similar. Before implantation, the surgeon, a qualified and trained surgical assistant, or a certified clinical perfusionist connects the pump and driveline and uses fluid to simulate the action of the pump (ie, wet-tests) on a separate sterile back table according to manufacturer's guidelines. In a standard sternal approach, the surgeon performs a midline sternotomy and opens the pericardium. A cardiopulmonary bypass is initiated in most cases, and the surgeon attaches the pump to the left ventricular apex using the sewing ring and coring device. The HeartMate II is larger and requires dissection of a preperitoneal pocket below the diaphragm to house the body of the pump and part of the inflow connection to the ventricular apex. The HVAD pump, however, is inserted directly into the left ventricle through the apical sewing ring, allowing the surgeon to house the entirety of the pump in the pericardium. The surgeon stretches the outflow graft and connects it end-to-side to the ascending aorta using polypropylene suture. For both systems, the blood exiting the pump is routed to the ascending aorta for distribution to the rest of the body by way of the outflow graft. Next, the surgeon tunnels the driveline through the abdominal wall and subcutaneous tissue and connects it to the controller.

The clinical perfusionist is an integral part of the procedure who ensures that the system is properly connected. During weaning of the patient from cardiopulmonary bypass and the transition to pump support, the perfusionist collaborates with the surgeon to maximize the flow without causing a "suck-down event," which occurs when fluid is evacuated from the chambers of the heart, causing ventricular collapse.

Complications

Implantation of a VAD is associated with multiple potential complications, which are often exacerbated by the patient's preexisting comorbidities. Common complications include

- bleeding,
- infection,
- neurologic events,
- respiratory dysfunction,
- life-threatening arrhythmias,
- right ventricular failure, and
- arterial and venous thromboembolism.

Less common complications include renal dysfunction, psychiatric events (eg, delirium), myocardial infarction, hypertension, hepatic dysfunction, hemolysis, immunologic compromise, device failure, and death.[5,7,8,12,13,18]

Injury to the right ventricle is often caused by pulmonary hypertension, increased central venous pressure, and/or the large volume of blood products delivered to the patient intraoperatively.[9] The cardiac surgeon monitors this situation by direct visual inspection, and the anesthesia team monitors the patient using transesophageal echocardiography analysis. Despite improved clinical outcomes with newer-generation continuous-flow devices, driveline or pump-related infections remain a primary concern after VAD implantation.[10,12,13] Patients with heart failure are generally predisposed to infections from a variety of factors, including poor nutrition and metabolic anomalies. In addition, these patients are often hospitalized for prolonged periods, making them susceptible to health care-associated infections,[12,13] especially when they may have multiple surgical incisions and implants that increase their vulnerability.[12] According to the REMATCH trial, 41% of all deaths in patients with pulsatile VADs were caused by sepsis, underscoring the necessity for strict sterile technique and careful medical and surgical management during implantation and in the immediate postoperative period.[13] Despite newer pump technology, this infection risk remains a valid concern. Typical reasons for a patient's readmission to the OR include hypotension, bleeding, cardiac tamponade, right ventricular failure, thromboembolism, and infection.[11]

On rare occasions, if bleeding persists intraoperatively, the surgeon may elect to delay closing the patient's sternum for 24 hours. The threshold for making this decision is

surgeon-dependent and typically involves packing the patient's chest with laparotomy sponges, covering the heart with a drained sterile IV bag affixed to the sternal borders with staples or polypropylene suture, and covering this with an antimicrobial incise drape. When the patient returns to the OR for sternal closure, chest radiography often will be required per hospital protocol to minimize the risk of retained surgical items. At our center, surgeons avoid delayed closure because it profoundly increases the risk of infection in an exceedingly vulnerable patient population.

In a life-threatening emergency situation with patients who have had VAD implantation, chest compressions should be avoided unless directed by the physician, because they can dislodge the VAD, causing irrevocable harm. Conversely, use of defibrillation or cardioversion will not compromise the VAD.[11] In the event of an arrest of an inpatient with a VAD, anesthesia and perfusion staff members should manage the VAD until the patient is stabilized or until the cardiac surgeon can intervene to relieve the initiating event.

PERIOPERATIVE NURSING CONSIDERATIONS

Successful device implantation and intraoperative care of a patient undergoing VAD implantation depend on a collaborative team whose members include cardiothoracic surgeons, VAD coordinators, surgical intensivists, cardiac anesthesia professionals, perioperative nurses, scrub technologists, pharmacists, perfusionists, and various ancillary staff members.[9,11] The sheer volume of personnel required to facilitate these procedures requires each individual to understand his or her unique responsibilities and scope of practice to ensure efficiency, organization, and concise communication between team members.

The patient's safety is the paramount concern with every task performed in the OR. To aid in uniform preparation for VAD implantation procedures, our team has recently developed virtual surgeon preference cards, using an online remote database. Virtual preference cards have become an invaluable component in our nursing process, because VAD implantation requires the acquisition of a large volume of highly specialized equipment, instrumentation, supplies, medications, and implants. The nursing team members have categorized VAD preference cards according to surgeon and surgical approach. Intraoperative VAD RNs are able to access and amend the virtual cards from their computer workstations in the OR in real time, providing an excellent resource for the entire team. Additionally, the RN care plans are based on potential complications related to long-term implants, immobility for extended time periods, and changes in family dynamics. The RN's leadership in organization and communication is crucial to the success of these procedures.

Nursing Care Plan

Table 2 is a care plan specific to the *Perioperative Nursing Data Set* diagnoses, interventions and outcomes.[19] In addition to the care plan, standard interventions apply to all perioperative patients, particularly cardiac patients. The discussion below includes important, specific VAD-related nursing activities.

Preoperative procedure preparation

For minimally invasive approaches, we have created a specialized VAD instrument set, which includes a chest tube passer; #1, #2, and #3 Richardson retractors; two sharp rakes; and a small self-retaining retractor. We have three of these instrument sets readily available in our OR. In addition to this instrument set, we routinely use a basic cardiac instrument set, the surgeon's specialty instrument set, chest retractors per surgeon preference, a regular or repeat sternal saw, internal defibrillator paddles, and partial occlusion clamps for minimally invasive approaches.

The intraoperative VAD RN ensures that all positioning and patient-care supplies are present and in good working order before the patient arrives. He or she consults with the surgeon and the anesthesia team to determine whether any additional supplies or instruments may be needed or whether there are patient-specific issues that require attention.

Preoperative checklist

Preoperative checklists are one way to help ensure that errors are reduced and never events (eg, wrong patient, wrong site, wrong procedure, wrong implant) do not occur. To decrease delays and ensure safe and efficient delivery of care, the intraoperative VAD RN verifies the following actions during his or her preoperative assessment:

- A VAD-specific consent is signed by the patient and the surgeon is present, in compliance with hospital protocol, before the patient is transferred to the OR.
- The patient confirms receiving education and voices his or her expectations regarding the procedure.
- The surgeon's orders for preoperative care have been followed, including whether prophylactic IV antibiotics have been administered.
- The patient is NPO for a time frame in compliance with hospital protocol.
- The correct implant is available, as well as a backup kit.
- A current blood type, screen, and antibody verification are present, and blood products are available.

Table 2. Nursing Care Plan for a Patient Undergoing Ventricular Assist Device Implantation[1]

Diagnosis	Nursing interventions	Interim outcome statement	Outcome statement
Risk for injury	• Confirms the patient's identity • Verifies the surgical procedure, site, and laterality • Ensures that the surgical site is marked • Verifies consent for the planned procedure • Implements protective measures before a surgical or invasive procedure • Evaluates the verification process for correct patient, site, side, and level of surgery • Ensures continuity of care • Provides care in a nondiscriminatory, nonprejudicial manner regardless of the setting in which care is given • Maintains patient confidentiality • Shares patient information only with those directly involved in care • Acts as a patient advocate by protecting the patient from incompetent, unethical, or illegal practices • Assesses baseline skin condition	The patient or designated support person verbalizes satisfaction that questions have been answered and that confidentiality has been maintained.	The patient's procedure is performed on the correct site, side, and level. The patient is the recipient of competent and ethical care within legal standards of practice.
Risk for imbalanced body temperature Ineffective thermoregulation	• Assesses risk for normothermia regulation • Assesses risk for inadvertent hypothermia • Assesses risk for inadvertent hyperthermia • Identifies physiological status • Reports deviation in diagnostic study results • Implements thermoregulation measures • Monitors body temperature • Monitors physiological parameters • Evaluates response to thermoregulation measures	The patient's temperature is greater than 36° C (96.8° F) at the time of discharge from the OR or procedure room.	The patient is at or is returning to normothermia at the conclusion of the immediate postoperative period.
Risk for imbalanced fluid volume Risk for deficient fluid volume	• Identifies factors associated with an increased risk for hemorrhage or fluid and electrolyte imbalance • Identifies physiological status • Reports deviation in diagnostic study results • Implements hemostasis techniques • Monitors physiological parameters • Establishes vascular access • Administers prescribed solutions • Collaborates in fluid and electrolyte management • Administers blood product as prescribed • Administers prescribed medications based on arterial blood gas results • Administers electrolyte therapy as prescribed • Evaluates response to administration of fluids and electrolytes	• The patient's vital signs are within expected range at discharge from the OR. • The patient's blood pressure and pulse are within expected range and remain stable with position changes at the time of transfer to postoperative intensive care unit. • Urinary output is within expected range at the patient's discharge from the OR. • Diagnostic study results are within expected parameters on the patient's discharge from the OR.	The patient's fluid, electrolyte, and acid-base balances are maintained at or improved from baseline levels.

(continued)

Table 2. *(continued)*

Diagnosis	Nursing interventions	Interim outcome statement	Outcome statement
Risk for perioperative positioning injury Risk for peripheral neurovascular dysfunction Risk for impaired skin integrity Risk for impaired physical mobility Ineffective protection Ineffective peripheral tissue perfusion	• Assesses baseline skin condition • Identifies baseline tissue perfusion • Identifies baseline musculoskeletal status • Verifies the presence of prosthetics or corrective devices • Identifies physical alterations that require additional precautions for procedure-specific positioning • Positions the patient • Implements protective measures to prevent skin/tissue injury due to mechanical sources • Applies safety devices • Uses supplies and equipment within safe parameters • Maintains continuous surveillance • Evaluates tissue perfusion • Evaluates musculoskeletal status • Evaluates for signs and symptoms of physical injury to skin and tissue	• The patient's pressure points demonstrate hyperemia for less than 30 minutes. • The patient's peripheral tissue perfusion is consistent with preoperative status at discharge from the OR or procedure room. • The patient is free from pain or numbness associated with surgical positioning.	The patient is free from signs and symptoms of positioning injury. Skin condition: The patient's skin is smooth, intact, and free from ecchymosis, cuts, abrasions, sheer injury, rash, or blistering. Neuromuscular status: The patient flexes and extends extremities without assistance. The patient denies numbness or tingling of extremities.
Ineffective breathing pattern Impaired gas exchange Ineffective airway clearance Risk for aspiration Impaired spontaneous respiration	• Identifies baseline respiratory status • Identifies physiological status • Reports deviation in diagnostic study results • Reports deviation in arterial blood gas studies • Monitors physiological parameters • Monitors changes in respiratory status • Uses monitoring equipment to assess respiratory status • Evaluates respiratory status	• The patient's arterial oxygen saturation (SaO_2) is within the expected range; the rate, depth, and symmetry of respirations are unchanged or improved from preoperative assessment; the patient's breath sounds are free from adventitious sounds. • Cognitive: The patient answers questions appropriately; the patient's memory is intact. • Vital signs: The patient's blood pressure, temperature, oxygen saturation as measured by pulse oximetry (SpO_2), and pulse are within expected ranges.	The patient's respiratory status is maintained or improved from baseline levels.
Decreased cardiac output Ineffective peripheral tissue perfusion	• Identifies baseline cardiac status • Assesses baseline tissue perfusion • Assesses tissue perfusion • Interviews the patient for history of vascular problems and surgical or invasive procedures • Monitors physiological parameters • Monitors changes in cardiac status • Uses monitoring equipment to assess cardiac status • Evaluates cardiac status • Evaluates tissue perfusion • Evaluates renal function • Identifies and reports the presence of implantable cardiac devices	• Cardiovascular status: The patient's heart rate and blood pressure are within expected ranges; peripheral pulses are present and equal bilaterally; the patient's skin is warm to the touch; the patient is free from cyanosis or pallor; capillary refill is less than 3 seconds. • Respiratory status: The patient's SaO_2 is within the expected range; the rate, depth, and symmetry of respirations are unchanged or improved from those of the	The patient's cardiovascular status is maintained at or improved from baseline levels. The patient's tissue perfusion is consistent with or improved from baseline levels.

Table 2. *(continued)*

Diagnosis	Nursing interventions	Interim outcome statement	Outcome statement
	• Reports deviations in diagnostic studies	perioperative assessment; the patient is free from adventitious breath sounds. • Skin condition (general): The patient's conjunctiva or mucous membranes are pink; the patient is free from cyanosis or pallor. • Renal status: The patient's output is greater than 30 mL/hour; the specific gravity is 1.010 to 1.030.	
Risk for infection Risk for delayed surgical recovery Risk for impaired skin integrity	• Assesses the patient's susceptibility for infection • Classifies surgical incision site • Implements aseptic technique • Protects the patient from cross-contamination • Initiates traffic control • Administers prescribed prophylactic treatments • Administers prescribed medications • Administers prescribed antibiotic therapy as ordered • Performs skin preparations • Monitors the patient for signs and symptoms of infection • Minimizes the length of invasive procedure by planning care • Maintains continuous surveillance • Administers care to incision sites • Administers care to invasive-device sites • Encourages deep breathing and coughing exercises • Evaluates factors associated with increased risk for postoperative infection at the completion of the procedure • Evaluates the progress of incision-site healing • Evaluates for signs and symptoms of infection through 30 days after the perioperative procedure	• The patient's incision site is free from signs or symptoms of infection and pain, redness, swelling, drainage, or delayed healing at the time of discharge from the hospital. • The patient has a clean, primarily closed surgical incision site covered with dry sterile dressing at the time of discharge from the OR. • The patient is afebrile and free of signs and symptoms of infection. • Preoperative and postoperative antibiotics were given according to recommended guidelines.	The patient is free from signs and symptoms of infection.
Acute pain	• Assesses pain control • Identifies cultural and value components related to pain • Implements pain guidelines • Implements alternative methods of pain control • Collaborates in initiating patient-controlled analgesia • Evaluates the patient's response to pain-management interventions	• The patient verbalizes control of pain. • The patient's vital signs at discharge from the OR are equal to or improved from preoperative values.	The patient demonstrates or reports adequate pain control.

(continued)

Table 2. *(continued)*

Diagnosis	Nursing interventions	Interim outcome statement	Outcome statement
Anxiety Fear Knowledge deficiency Compromised family coping Ineffective coping Decisional conflict	• Identifies the patient's psychosocial status • Assesses baseline neurological status • Assesses the patient's coping mechanisms • Assesses the patient for signs and symptoms of anxiety or fear • Assesses the home-care environment • Maintains a calm supportive atmosphere • Observes for increased anxiety demonstrated through behavior • Provides an atmosphere of care and concern • Identifies sensory impairments • Identifies barriers to communication • Identifies the educational needs of the patient and designated support person • Implements measures to provide psychological support • Includes patient or designated support persons in perioperative teaching • Explains expected sequence of events • Provides status reports to designated support person • Evaluates psychosocial response to plan of care • Evaluates response to instructions • Develops individualized plan of care • Elicits perceptions of surgery	• The patient or designated support person verbalizes the sequence of events to expect before and immediately after surgery. • The patient and family members describe the prescribed postoperative regimen accurately. • The patient and family members verbalize feelings of decreased anxiety and understanding of instructions.	The patient or designated support person demonstrates knowledge of the expected psychosocial responses to the procedure.
Ineffective management of the therapeutic regimen by the family Knowledge deficiency	• Verifies the patient's allergies • Identifies the patient's psychosocial status • Assesses psychosocial issues specific to the patient's medication management • Includes patient or designated support persons in perioperative teaching • Provides instruction about prescribed medications • Evaluates response to instruction • Evaluates response to instructions about prescribed medications	• The patient, family member, designated support person, or legal guardian verbalizes realistic expectations regarding the effect of medications on postoperative recovery before the patient's discharge from the hospital. • The patient, family member, designated support person, or legal guardian describes medication side effects to report at time of discharge from the hospital. • The patient, family members, designated support person, or legal guardian can state the correct dose, frequency of administration, and purpose of each prescribed medication at the time of discharge from the hospital.	The patient or designated support person demonstrates knowledge of medication management.

1. *Petersen C.* Perioperative Nursing Data Set. *3rd ed. Denver, CO: AORN, Inc; 2011.*

- Adequate hair removal from the chest and bilateral groin areas has been performed using clippers, in compliance with hospital protocol, before the patient is transferred to the OR.
- The patient has taken a preoperative shower(s) and used chlorhexidine wipes in accordance with hospital protocol before his or her transfer to the OR.
- Communication has been initiated between the intraoperative VAD RN and either nursing unit RNs or the holding room RN regarding transport plans (these may vary based on patient condition, inotropic drips, and other care requirements), and a postoperative intensive care unit bed is available.

Preoperative Care

The arrival at the OR of a patient undergoing a VAD implantation procedure marks a significant turning point in the patient's care, and he or she is often anxious and fearful. The entire perioperative team must be sensitive to the patient's needs and help provide comfort and a sense of security before induction, regardless of other responsibilities. Additionally, communication with the family is imperative, because they are a key component of the patient's health care team. At our center, the intraoperative VAD RN maintains close contact with a designated family member via telephone throughout the procedure. In addition, the intraoperative VAD RN verifies the availability of the regional industry representative in the event that the surgeon or first assistant has questions pertaining to the assembly of the VAD, its components, or its functionality. Preoperatively, the intraoperative VAD RN coordinates with the perfusionist for the transport of the patient to and from the procedural areas.

The intraoperative VAD RN ensures that the necessary equipment is present and that a regional industry representative is readily available to interrogate the patient's pacemaker or implantable cardioverter defibrillator and to program pacing modalities as requested by the anesthesia professional and the surgeon.[9]

Before transporting the patient to the OR, the intraoperative VAD RN applies a multilayered, soft silicone-foam pressure dressing on the patient's sacrum to prevent skin breakdown in the perioperative and immediate postoperative periods. A recent study[20] has shown that using this prophylactically reduces the occurrence of pressure ulcers in critically ill patients by as much as 10%. An informal review undertaken by our cardiac intensive care unit personnel has preliminarily shown these dressings to reduce sacral skin problems at our center as well.

Intraoperative Care

When the patient arrives at the OR, the intraoperative team executes a smooth patient transfer from the stretcher to the OR table. After induction and intubation, the team places the patient in the supine position with modified frog-leg positioning. The intraoperative VAD RN pads all bony prominences and places an axillary chest roll under both axilla for sternotomy and under the left axilla for left thoracotomy, for maximum surgical exposure. The OR beds at our institution are outfitted with thick foam padding, which aids in reducing positioning injuries.

The intraoperative VAD RN limits OR traffic by ensuring that only necessary personnel are present for the procedure. This task is aided by laminated signs indicating "VAD IMPLANT IN PROGRESS: NECESSARY PERSONNEL ONLY," which appear on all doors during pump preparation and throughout the entire intraoperative period. The intraoperative VAD RN and scrub person prepare a separate back table for pump assembly and wet-testing, and both team members monitor and maintain strict aseptic technique in all phases of the procedure, including placement of vascular access lines, insertion of the indwelling urinary catheter, delivery and assembly of pump components, and dispensing medications to the sterile field. During the procedure, the intraoperative VAD RN delivers various antimicrobial medicines to the sterile field, including

- antibiotic sternal paste;
- antibiotic irrigation; and
- 1 g of absorbable gelatin powder, 5,000 units of thrombin, and 0.5 g of vancomycin paste for the driveline site (all in accordance with patient allergies and surgeon preference).

The intraoperative VAD RN applies external defibrillator pads to the patient's chest and connects them to the defibrillator device before incision. He or she delivers internal defibrillator paddles to the sterile field and ensures that they are ready for use after the surgeon exposes the heart. After the VAD is implanted the intraoperative VAD RN should set up the accessory monitor to display VAD data and ensure that the surgeon and entire team can see the monitor. The team must pay special attention to the driveline site; minimize trauma and ensure maximal protection using a securing stitch, surgical glue, small

IV drain sponges, and a small occlusive surgical dressing; and exert care when repositioning and transferring the patient.[5,11]

IMPLANTS

Each implant system must be stored in a secure location. We use separate mechanically locked or keypad-coded storage areas for each of the two systems we stock. Additionally, we developed preprinted implant sheets that staff members use to pull necessary supplies for each VAD implant (Figures 2 and 3). In an effort to reduce confusion and errors when opening implants, the cardiac surgery manager and clinical staff leader gather equipment for these procedures using the implant sheets specific to the type of VAD procedure. They also transfer serial numbers and expiration dates from the inventory boxes to the implant sheet. The intraoperative VAD RN then references this sheet to enter the implant documentation into the patient's electronic medical record and to cross-reference charges to the patient. This systematic approach has streamlined our process, helping staff members to work efficiently and document accurately. Implant personnel are responsible for ordering and maintaining adequate par levels of each VAD component, ensuring a backup pump kit consisting of an entire set of each integral component is stocked for every implant procedure. This kit is used in the event parts are contaminated or deemed nonfunctional during the procedure. One designated staff member (eg, intraoperative VAD RN, perfusionist) is responsible for opening VAD components to avoid miscommunication and inadvertent errors in delivery to the sterile field and to diminish waste. Our management team is responsible for submitting tracking information on a vendor-provided device tracking form.

Description	Item number	Catalog number	Serial number	Expiration date	Amount	Comments in VPIMS
Items actually implanted:						
Implant kit with sealed grafts	117430	106015			1	
Pocket controller	117426	106762			1	In kit; no charge
Implant accessory kit	N/A	N/A			1	In kit; no charge
Sealed inflow conduit	110049	104142			1	In kit; no charge
Sealed outflow graft with bend relief	91275	103393			1	In kit; no charge
Sealed outflow bend relief collar	117346	107315			1	In kit; no charge
Apical sewing ring	90568	1065			1	In kit; no charge
Used not implanted:						
Pocket controller (not in kit)	117426	106762			1	
Power module	109508	1340			1	
Universal battery charger	109509	1440			1	
14 volt battery clip set	109510	2865	No serial number if needed		2	
14 volt batteries	109725	2465	No serial number if needed		2	
Travel case	90715	1260	No serial number if needed		1	
Designate which pocket controller is primary and which is backup.						

Figure 2. Thoratec HeartMate II preprinted implant sheet used to pull necessary supplies for each VAD implant. VPIMS = electronic medical record. *Adapted with permission from Vanderbilt University Medical Center, Nashville, TN.*

Description	Item number	Catalog number	Serial number	Expiration date	Amount	Comments in VPIMS
Implanted:						
HeartWare (HW) pump only	115140	1103			1	
Outflow graft	115144	1125			1	
Used but not implanted:						
HW controller kit	115090	1403US		N/A	1	AC adapter with power cord number
HW controller kit	115090	1403US		N/A	1	AC adapter with power cord number
Patient pack	115091	1475		N/A	1	
Battery charger	115087	1600US		N/A	1	
Battery	115088	1650		N/A	1	
Battery	115088	1650		N/A	1	
Battery	115088	1650		N/A	1	
Battery	115088	1650		N/A	1	
Battery	115088	1650		N/A	1	
Battery	115088	1650		N/A	1	
Driveline extension cable	115142	100US			1	
Surgical tool kit	115139	1318			1	
Circulators:						
Mark the controllers as primary or backup						

Figure 3. HeartWare preprinted custom implant sheet. AC = alternating current; VPIMS = electronic medical record. *Adapted with permission from Vanderbilt University Medical Center, Nashville, TN.*

It is also their responsibility to return explanted VADs to the company for analysis.

STAFFING AND EDUCATION

To establish and maintain an accredited VAD program, The Joint Commission requires annual documented staff member education. Our center uses a self-paced, web-based educational slide program developed by perioperative educators. Nursing staff members are required to view the online slides and complete a certification quiz demonstrating an understanding of VAD safety protocols. Additionally, cardiac surgery managers ensure intraoperative staff member competency through minimum procedure-completion requirements and documented competencies (Figure 4).

We have developed specialized intraoperative VAD nursing teams whose members are deemed "VAD knowledgeable" and who collaborate with the anesthesia team, perfusionists, cardiac surgeons, and ancillary staff to promote coordinated and efficient delivery of care. Nursing teams are composed of one intraoperative VAD RN, one scrub person, and one surgical first assistant. We have found it helpful, because of the busy nature of these procedures, to include a flexible "resource" staff member (either a scrub person or an RN) to assist as needed.

CONCLUSION

The arrival in the OR of a patient undergoing a VAD implantation marks a significant turning point in a long course of treatment. Successful device implantation requires extensive planning, interdisciplinary communication, collaborative effort, and dedication to clinical excellence. Perioperative nursing care includes meeting a broad spectrum of patient needs and procedure complexities. The intraoperative VAD RN must be able to prioritize, delegate, and participate in teamwork to promote safe, quality care. The use of continuous-flow VAD models to sustain and improve patients' quality of life presents a unique

Perioperative Services Competency Assessment Vanderbilt University Medical Center

HeartWare	Interpretation	Rationale
• Verbalizes the physiology of the HeartWare ventricular assist device (HW HVAD)	• The HW HVAD is a left ventricular assist device that is placed into the patient's native left ventricle to assist the pumping of the left ventricle • The HW HVAD acts as a conduit being placed into the left ventricle and then attached to the aorta which assists circulation	• The US Food and Drug Administration has approved the HW HVAD to use as a bridge to transplant, but has not approved it as destination therapy.
• Is able to name the components of the HW HVAD system	• Insulated blood pump • Outflow graft • Percutaneous lead	• Reduces the chance for error • Aids in the assembly and handling of the device
• Verbalizes the required equipment and supplies necessary for HW HVAD implantation	Instrumentation includes • Cardiac basic tray • Cardiac sternal saw • Internal defibrillator paddles • Surgeon's special instruments • Favaloro Morris retractor • Partial occlusion clamps tray • Ventricular assist device tray • Repeat sternotomy saw (if patient has previous sternotomy) • Mayo stand basin Supplies include • HW HVAD pump kit • implantation documentation forms • Charge sheet • Check surgeon preference cards for other supplies	• Reduces the chance for error by the nurse being prepared with correct instrumentation and supplies
• Completes the HW HVAD surgical module in the Learning Exchange	Date of completion ____/_____/____	Patient safety

• For each required competency or skill, the orientee will complete a preclinical self-assessment. • In the clinical area, the preceptor will validate the required competency or skill and the method used to evaluate this.	Self-assessment 1 = Experienced 2 = Needs practice or assistance 3 = Has never participated in the procedure N/A	Preceptor validation and evaluation method D = Return demonstration V = Verbal understanding O = Observation

Required competency or skill	Page number	Self-assessment score	Classroom evaluation method	Preceptor evaluation method	Clinical validation by preceptor or manager Name and date
HeartWare HVAD	1				

I have successfully demonstrated competency as stated in the area indicated above and understand that I am accountable for applying the above criteria to clinical practice.
Employee signature_____ Date_____

Employee has successfully demonstrated competency as stated in the area indicated above in the clinical setting.
Manager's signature_____ Initials_____ Date_____

Figure 4. Minimum procedure-completion requirements and documented competencies. *Adapted with permission from Vanderbilt University Medical Center, Nashville, TN.*

opportunity for nurses to experience clinical growth and expand their knowledge base, and it provides renewed hope for patients and their families.

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Editor's notes: *HeartMate II and HeartMate III are registered trademarks of the Thoratec Corporation, Pleasanton, CA; HeartWare HVAD and the HeartWare Miniature Ventricular Assist Device are registered trademarks of HeartWare, Framingham, MA. Jarvik-7 is a registered trademark of Jarvik, Inc, New York, NY; Novacor LVAD is a registered trademark of Novacor, Rueil-Malmaison, France.*

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Continuing Education: Ventricular Assist Device Implantation: Perioperative Nursing Considerations 3.5 CE

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PURPOSE/GOAL

To provide the learner with knowledge specific to ventricular assist device (VAD) implantation.

OBJECTIVES

1. Discuss cardiomyopathy.
2. Describe mechanical circulatory support.
3. Identify the complications related to VAD implantation.
4. Describe the nursing care of patients undergoing VAD implantation.

The Examination and Learner Evaluation are printed here for your convenience. To receive continuing education credit, you must complete the online Examination and Learner Evaluation at *http://www.aornjournal.org/content/cme*.

QUESTIONS

1. Which of the following statements are true about cardiomyopathy?
   1. The heart muscle becomes inflamed and weakened.
   2. Mechanical or electrical dysfunction causes ventricular dilation.
   3. It occurs only as a result of a medical condition.
   4. It can occur in the absence of other cardiac conditions.
   5. It has five basic categories.

   a. 4 and 5 b. 1, 2, and 4
   c. 1, 2, 3, and 4 d. 1, 2, 3, 4, and 5

2. Physicians commonly treat heart failure with
   1. beta-blockers, angiotensin-converting enzyme inhibitors, and diuretic therapy.
   2. heparin and antiarrhythmogenic medications.
   3. implantable cardioverter defibrillators and biventricular pacemakers.
   4. heart-valve replacement.

   a. 1 and 3 b. 2 and 4
   c. 1, 2, and 4 d. 1, 2, 3, and 4

3. The demand for acceptable donor organs and comorbidities (eg, morbid obesity, smoking) often preclude patients with end-stage heart failure from transplantation candidacy and contribute to a rising number of patients requiring mechanical circulatory support (ie, VAD implantation) as their health declines.

   a. true b. false

4. Eligibility criteria for VAD implantation include
   1. failure to respond to medical management for at least 45 of the preceding 60 days.
   2. dependence on a balloon pump for seven days.
   3. dependence on IV inotropes for 14 days.
   4. a left ventricular ejection fraction of less than 25%.
   5. failure to respond to surgical intervention.
   6. demonstrated functional limitations.

   a. 1, 3, and 5 b. 2, 4, and 6
   c. 1, 2, 3, 4, and 6 d. 1, 2, 3, 4, 5, and 6

5. The Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH) trial showed VAD implantation
   a. significantly decreased survival rates.
   b. was indicated only for bridge-to-transplantation patients.
   c. significantly increased survival rates.
   d. was indicated only for destination-therapy patients.

6. Complications associated with VAD implantation include
   1. respiratory dysfunction.
   2. bleeding.
   3. life-threatening arrhythmias.
   4. infection.
   5. neurologic events.
   6. right ventricular failure.

   a. 1, 3, and 5 b. 2, 4, and 6
   c. 1, 2, 3, 4, and 6 d. 1, 2, 3, 4, 5, and 6

7. More commonly, patients experience complications that include renal dysfunction, psychiatric events (eg, delirium), myocardial infarction, hypertension, hepatic dysfunction, hemolysis, immunologic compromise, device failure, and death.
   a. true b. false

8. The patient's arrival at the OR marks a significant turning point in the patient's care, and he or she is often
   a. anxious and wary. b. anxious and fearful.
   c. cautiously excited. d. depressed and fearful.

9. Examples of nursing interventions that should be included in the patient's plan of care because of the patient's compromised cardiac status include
   1. identifying baseline cardiac status.
   2. reporting deviation in diagnostic study results.
   3. monitoring changes in cardiac status.
   4. using monitoring equipment to assess cardiac status.
   5. identifying the presence of implantable cardiac devices.
   6. evaluating cardiac status.

   a. 1, 3, and 5 b. 2, 4, and 6
   c. 1, 2, 3, 4, and 6 d. 1, 2, 3, 4, 5, and 6

10. When repositioning and transferring the patient, the team must pay special attention to
    a. the connecting hoses. b. the VAD pump.
    c. the driveline site. d. body position.

Continuing Education: Ventricular Assist Device Implantation: Perioperative Nursing Considerations 3.5 CE

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This evaluation is used to determine the extent to which this continuing education program met your learning needs. The evaluation is printed here for your convenience. To receive continuing education credit, you must complete the online Examination and Learner Evaluation at *http://www.aornjournal.org/content/cme*. Rate the items as described below.

OBJECTIVES

To what extent were the following objectives of this continuing education program achieved?

1. Discuss cardiomyopathy.
   Low 1. 2. 3. 4. 5. High
2. Describe mechanical circulatory support.
   Low 1. 2. 3. 4. 5. High
3. Identify the complications related to ventricular assist device (VAD) implantation.
   Low 1. 2. 3. 4. 5. High
4. Describe the nursing care of patients undergoing VAD implantation.
   Low 1. 2. 3. 4. 5. High

CONTENT

5. To what extent did this article increase your knowledge of the subject matter?
   Low 1. 2. 3. 4. 5. High
6. To what extent were your individual objectives met?
   Low 1. 2. 3. 4. 5. High
7. Will you be able to use the information from this article in your work setting?
   1. Yes 2. No
8. Will you change your practice as a result of reading this article? (If yes, answer question #8A. If no, answer question #8B.)

8A. How will you change your practice? (*Select all that apply)*

1. I will provide education to my team regarding why change is needed.
2. I will work with management to change/implement a policy and procedure.
3. I will plan an informational meeting with physicians to seek their input and acceptance of the need for change.
4. I will implement change and evaluate the effect of the change at regular intervals until the change is incorporated as best practice.
5. Other: _____

8B. If you will not change your practice as a result of reading this article, why? (*Select all that apply*)

1. The content of the article is not relevant to my practice.
2. I do not have enough time to teach others about the purpose of the needed change.
3. I do not have management support to make a change.
4. Other: _____

9. Our accrediting body requires that we verify the time you needed to complete the 3.5 continuing education contact hour (210-minute) program: _____