Simply a ventricular assist device (VAD) is an implantable mechanical pump that helps pump blood from the lower chambers of the heart (the ventricles) to the rest of the body. VADs are used in people who have weakened hearts or heart failure. Although VADs can be placed in the left, right or both ventricles of the heart, they are most frequently used in the left ventricle. When placed in the left ventricle they are called left ventricular assist devices (LVADs). When they have been placed in the right ventricle, they are called right ventricular assist devices or (RVADs) and when they assist both the left and right, they are BiVADs.

Heart failure is a “clinical syndrome in which the hearts mechanical performance is compromised so that cardiac output cannot meet the body’s needs”1. Often times this heart failure will develop over the course of the patient’s life. The heart becomes weak and unable to maintain needed cardiac output. This can be caused by: chronic hypertension, heart disease, congenital defects, infections, mechanical damage or injury.

Many times the first line treatment of these conditions can be done with medications. These are all done to change the workload of the heart. Medications such as Digoxin will increase the strength of the heart. Diuretics like Lasix to control fluid shifts. Beta blockers such as Metoprolol to slow the heart rate down and ACE inhibitors like Lisinopril to cause vasodilation.

When these medications don’t take care of the patient’s condition, they will then usually have surgery to repair or replace heart valves. If the surgery does not take care of the situation, then the patient will have a VAD placed.

**TYPES OF VADs:**

In 1982 the very first VAD was created called the Jarvic-7. The first patient it was implanted in survived 112 days while the second patient survived 620 days. In 1991, the FDA stopped use of the Jarvik-7 because of infections, low survival rates and an increase in thrombosis.
INDICATIONS FOR USE OF A VENTRICULAR ASSIT DEVICE:

- **Waiting for a heart transplant.** A patient may have a VAD implanted temporarily while he/she waits for a donor heart to become available. A VAD can keep blood pumping despite a diseased heart and will be removed when the new heart is implanted. When a VAD is implanted while a patient is waiting for a heart transplant, it's referred to as a "bridge to transplant."

- **Temporary heart failure.** If a patient’s heart failure is temporary, the doctor may recommend implanting a VAD until the heart is healthy enough to pump blood on its own again. It's also possible a patient may have a VAD implanted for a short time while recovering from heart surgery. He/she may have a VAD implanted for only a few weeks or months. RVADs are often temporarily implanted after some heart surgeries. An RVAD can help keep blood flowing from the right ventricle to the lungs.

- **Patient is not a candidate for a heart transplant.** VADs are increasingly being used as a long-term treatment for people who have heart failure, but aren’t good candidates for a heart transplant. A VAD can improve the patient’s quality of life. When a VAD is implanted as a permanent treatment for heart failure, it’s referred to as destination therapy.

**LVAD Functionality**

Although there are several types of LVADs the principle behind them is the same. The principle behind the LVAD is to assist the left ventricle with its ability to generate cardiac output. Surgically implanting the VAD and augmenting blood flow through the pump assists the left ventricle with cardiac output. Blood follows the normal path through the heart until it reaches the left ventricle. The implanted LVAD has a cannula placed in the apex of the heart that drains the blood from the left ventricle into the system pump.

Blood is then pumped into the aorta. The internal pump is placed in the left lower chest, generally under the left rib cage.
A percutaneous cable, also called the driveline, exits the abdominal wall, connecting the internal pump to the external controller, which is connected to an electrical source (batteries or an AC-power based unit). The controller is the brains of the device and contains the settings, alarms and diagnostic information about the pump.

There have been 4 generations of VAD devices. The 1st generation was called a “pulsatile” because it actually mimicked the way the heart functioned. There was actually a bladder that filled with blood and then forced the blood into the Aorta. The device was driven by air and when the battery failed, you had an external hand pump to use. The Heartmate XVE was the most common device.

The 2nd generation VADs became “non-pulsatile”. There was a pulse felt if the device was assisting the heart and no pulse if the device was in by-pass. You could actually hear a “humming” with the device and an EKG would look normal. You would notice some changes to the SpO2 and even the B/P. The Heartmate II was the most common device.
In the 3rd generation devices there was a change to the impeller in the pump. It was now a magnet that drove the device so the “humming” of the second generation was now gone. This was also an improvement to the pump in that there was less damage to the cells.

The next generation will be the 4th generation device and is in development and could completely replace a patient’s ventricle. It is miniaturized and is a less invasive surgery for placement. It is also thought that this device will be wireless running off of Bluetooth with no drivelines.

Assessment
Although most of the assessment of a VAD patient is the same as any other patient, there are minor differences to keep in mind. In general, be extremely careful not to cut, twist or bend the driveline coming from the patient’s abdomen. Remember, this is connecting the power source to the pump and controlling the function of the pump.

Most of the 911 calls that we tend to get with these patients tend to be non-VAD related issues such as altered LOC which could be from blood glucose levels, stroke or overdoses. If you’re called for stroke symptoms, it’s important to establish a time of onset, document a neurological exam and expedite transport. Infections and sepsis related because there may be an open wound or infection where the drive line enters the chest. The patient may fall due to syncope, vertigo or other issues causing trauma. You may be called for epistaxis or GI bleeding because these patients will be on anticoagulation medication. A determination about the severity of bleeding and amount of blood loss should guide your fluid resuscitation as usual.

Start with the ABCs as normal. When you get to “C,” the normal assessment will be changed slightly. Although some VADs produce pulsatile flow, most VADs use continuous flow technology, creating a non-pulsatile continuous flow. This means most patients with a VAD will not have a palpable pulse, and unfortunately, taking a blood pressure with a manual cuff and stethoscope will rarely allow you to hear a pressure.

If available, use an automatic non-invasive blood pressure (NIBP) device, and you may be successful. Although rarely available on an EMS unit, a Doppler unit is the best way to obtain a blood pressure on a VAD patient. When using a Doppler, you use a normal cuff but listen with the Doppler instead of a stethoscope. The first sound heard is approximately equivalent to the mean arterial pressure (normal Doppler pressure range is 60–90 mmHg). A pressure of 60–90 mmHg is considered acceptable.

Another barrier to normal assessment is pulse oximetry. Oximetry readings may not be accurate due to weak or absent pulses. Assessing the patient’s mental status, skin and lips are likely to be most helpful in determining the overall condition of the patient’s oxygenation, volume status and to help you decide how critical their condition may be. Note that you may or may not hear normal heart tones on VAD patients.
Outside of a normal physical exam, it’s important to assess whether the pump is functioning. Listen with a stethoscope over the pump pocket at the lower left rib margin on the anterior chest. A distinct hum will be heard if the device is running. If possible, use the VAD coordinator and family in the event the VAD is alarming because they’re the equipment experts.

If the VAD is alarming, make sure the driveline and two sources of power (dual batteries or AC power) are connected to the system controller. Make sure you have an inverter in your ambulance and that it’s in good, working condition. Contact the VAD coordinators who will help you trouble shoot the alarm. There are several types of VAD in use. The patient will have an emergency instruction booklet specific to their VAD for you to reference until you reach the coordinator.

If the VAD pump is not working or is stopped, the patient will go back into heart failure. Some patients may tolerate this condition well, while others may decompensate rapidly.

In the event of a pump failure, contact the VAD coordinator for guidance and instruction. Restarting a pump that has been stopped isn’t recommended because it will increase the patient’s risk of stroke or thromboembolism. This is due to the stagnant blood that may have developed in the system while the pump was off.

**Care and Transport**

Care and transport should be guided by the VAD coordinator and your SOPs. How do we know the patient is in cardiac arrest if they don’t have a pulse? You need to evaluate everything else. Check the patient’s mental status, breathing and skin parameters. In regards to CPR there are a few considerations to consider. The pump is circulating blood through the heart and that is what we are doing when we do chest compression. Where the VAD attaches to the heart can actually become dislodged causing blood to rapidly escape the heart and into the chest cavity. The VAD coordinator will know if we should do CPR. Doing CPR may be device specific and remember that our SOP’s do allow us to do compressions.

Defibrillation can be done normally for a patient in V-Fib. Do not disconnect the VAD controller. Pad placement should be done in the Anterior/Posterior and stay at about the nipple line and away from the internal pump.

When transporting a patient with a VAD to the hospital, ask if they have an emergency kit prepared as many will have this already set up. If not, make sure they have 2 batteries connected. Then bring spare batteries and controller, charger for the batteries and an alternate power source for a home or car. Remember that the patient and their family are the experts in the device and will know what is normal and what is not normal. Here is a quick list of Do’s and Don’ts for VAD patients.

**Do:**

- Follow ABC’s
- Call VAD coordinator as soon as possible
- Listen to the family, they often know more than we do
- Reference the instruction booklet or card for the specific device the patient has
- Bring all VAD equipment to the hospital
- Keep patient on two good power sources at all times.
Don’t:

- Don’t ever disconnect a percutaneous lead from the system controller
- Don’t ever disconnect both power leads at the same time
- Don’t ever expose VAD equipment to water
- Don’t open or view exit or entry site.


**Left Ventricular Assist Device (LVAD) Patients [BLS]**

LV assist device (LVAD): Battery operated, mechanical pump surgically implanted next to native heart. A tube pulls blood from LV into pump that bypasses aortic valve to send blood directly into aorta. Purpose: help a weakened ventricle.

1. **CALL LVAD Coordinator listed on patient information sheet for instructions**

   - EMS personnel are authorized to follow directions of the LVAD Coordinator

2. Patient may or may not have a peripheral pulse or normal BP at any time; SpO₂ registers if perfusion is present

3. Evaluate perfusion based on mental status, skin signs

4. **CHEST COMPRESSIONS ARE ALLOWED if patient is unconscious and non-breathing.** see below.
   - Follow all other BLS and ALS protocols.

5. Patient may be defibrillated, as necessary for V-fib with loss of consciousness, without disconnecting the pump.

6. Do not defibrillate over the pump; defibrillate at nipple line or above. Anterior-posterior pad placement preferred.

7. ECG waveforms may have a lot of artifact due to the device.

8. Patients will often have pacemakers and/or Internal Cardioverter Devices (ICDs).

9. Waveforms may be flat; without amplitude in spite of accurate readings – i.e. pulse ox.

10. Patient should have a binder with record of daily VAD parameters.

11. Patients will be on anticoagulation medications

12. NO MRIs - CT Scans are ok; avoid water submersion; avoid contact with strong magnets or magnetic fields

13. **Never** remove both sources of power (batteries) at the same time!
Ventricular Assist Devices

POST Test

Name: _____________________________ Date: ______________________________ DEPT: _______________________

(CPRINT CLEARLY)

Circle one: EMT-B EMT-P PHRN

1. List three types of VADs.

2. What is the principle behind use of a VAD?

3. List the 4 main components of a VAD.

4. Explain how your assessment findings will differ for a patient with a VAD.

5. It is normal for VAD patients to be on anticoagulants. True False

6. List three resources you have if the pump is alarming.
7. What should you bring with you when transporting a patient with a VAD?

8. When defibrillating a patient with a VAD, what must you be careful not to do?

9. You should never do chest compressions on a patient that has a VAD. True False

10. All ACLS drugs may be given to a patient with a VAD. True False

If you are NOT a member of the McHenry Western Lake County EMS System, Please include your address on each optional quiz turned into our office. Our mailing address is: Northwestern Medicine – McHenry Hospital EMS, 4201 Medical Center Drive, McHenry, Illinois 60050. We will forward to your home address verification of your continuing education hours.

If you ARE a member of our EMS System, your credit will be added to your Image Trend record. Please refer to Image Trend to see your current list of continuing education credits. Any questions regarding this can be addressed to Cindy Tabert at 224-654-0160. Please fax your quiz to Cindy Tabert at 224-654-0165.