Left Ventricular Assist Devices (LVADs)
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Take Home Points

- The mean arterial pressure can be determined in patients with LVADs using a manual blood pressure cuff or arterial line.
- Low mean arterial pressure in LVAD patients may be due hypovolemia, hemorrhagic shock and infection.
- If an LVAD patient truly has cardiac arrest, do chest compressions.

- It used to be that pulseless meant dead but we are seeing increasing numbers of patients with left ventricular assist devices (LVADs).
- When the patient presents to your ED, contact the regional LVAD team if you don’t have one in your hospital. You will need their help in managing these patients. While you are waiting to hear from them, you need to be comfortable managing these patients for their initial phase.
- These patients do not have pulse. The pump is a linear flow device. The pump was placed because they had heart failure. It replaces the pulse with continuous flow and arterial pressure in these patients.
- How do you know if they have perfusion? What is their mental status? Look at the capillary refill. Feel the hands and feet to see if they are warm or cold.
- Auscultate the patient. Listen for the LVAD hum. It sounds similar to a dishwasher with a low pitched continuous hum.
- Because this is continuous flow, you won’t get a typical systolic or diastolic reading. LVADs only have mean arterial pressures. This is the only number you care about. Look around your ED for a manual cuff. Get a Doppler machine. Inflate the blood pressure cuff and place the Doppler over the brachial artery. Slowly release the blood pressure cuff and listen for the first sound. You won’t hear the usual Korotkoff sounds you normally hear. The single sound is the mean arterial pressure.
- How can you monitor that blood pressure? You can place an arterial line in the patient. This allows you to monitor the blood pressure continuously in the patient while administering inotropes and pressors. Your goal is between 70 and 90 mmHg. You don’t want to go any lower than 70 mmHg due to hypoperfusion. However, a MAP greater than 90 mmHg can be harmful to the patient because these devices are afterload sensitive. If you place too much stress on the motor due to resistance, it can hurt the pump.
- What if the device is alarming? It is first important to know the components of the LVAD system so you can troubleshoot.
- The motor of the LVAD is implanted in the patient. This sits in either the thoracic compartment or the abdomen.
  - There are inflow and outflow cannulas. The inflow cannulas pull blood from the left ventricle. The outflow cannulas put it back into the ascending aorta.
  - There are batteries worn by the patient. There are usually two. These are worn on suspenders, one on each side.
  - There is a cable connecting it to the controller. The controller is the brains of the operation. This controls the speed and monitors what is happening the patient.
The drive line goes from the controller into the patient’s skin and connects to the LVAD. It gives the LVAD information about what to do for the patient.

- **What should you do if the alarm is going off?** Don’t freak out. You can’t do anything bad to the controller except unplug it.
  - On the controller panel, there are some lights. One indicates that the LVAD is running. You want this light on.
  - There is a button that tells you the battery life. These patients often have extra batteries. Plug them in and make sure they are fully charged. You may be able to plug them into an AC outlet.
  - The button that hooks to the display is the most important. This tells you what exactly is alarming on the patient. You can scroll through by pushing this button. You might see something like “suction event”, “low battery”, “driveline disconnected”, “LVAD stopped.” You may not know what is going on but it is important to communicate this to the LVAD team to determine what to do next.
  - You can’t change the settings of the LVAD. These are preprogrammed by the LVAD coordinators. There is nothing you can do to turn off the LVAD except unplug it.

## CASE

**A 55 year old woman complains of a syncopal event. Her MAP is 40 mmHg. What diagnosis should you consider and how you should you proceed with management?**

- **The first approach is to assume the patient is hypovolemic until proven otherwise.** Give the patient a fluid bolus, about 500 mL to 1000 mL. Many of these patients, prior to receiving the LVAD, were heart failure patients and automatically fluid restricted themselves. Err on the side of fluids. The LVAD can handle it.

- **Other reasons that patients may be hypovolemic include GI bleed.**
  - Be sure to get your ultrasound. This will help you find out why the MAP is low. You might notice that the LV, RV and IVC are small. This indicates hypovolemia.
  - Don’t forget to get labs. For the most part, these are the usual labs; CBC, CMP, type and screen. Also, get a LDH and haptoglobin. These can help detect hemolysis.
  - **Infection.** There are multiple reasons an LVAD patient might have an infection.
    - They get pneumonias and urinary tract infections just like everyone else.
    - They may develop driveline infections. The wire exits the controller and enters the patient’s skin. This can serve as a nidus of infection. Look for redness, purulence or tenderness in that area.
    - Use broad spectrum antibiotics such as vancomycin and piperacillin-tazobactam. These patients have likely been in the hospital and exposed to MRSA and Pseudomonas. In addition, make sure you cover GI bugs, especially if the LVAD is implanted in the abdomen.
  - **Pump thrombosis could be another cause of hypotension.** This occurs in up to 10% of patients with LVADs. A clot can form in the pump. This is an emergency. The mean arterial pressure will be low due to impedance of forward flow. There may be a low flow alarm. The pump speed will be high. The LVAD tries to increase cardiac output. You will hear a choppy sound compared to the usual constant dishwasher sound. Look with your ultrasound. If it is a pump thrombosis, you will see a small left ventricle and a large right ventricle. Consider this like a pulmonary embolism in the system.
  - **Patients may have low blood pressure due to right ventricle failure or right ventricular infarction.** These patients depend on the RV as preload into the left ventricle. If the RV fails, they will have a bad blood pressure. Bedside echo can also help you evaluate the right ventricle for targeted failure.
  - **What is a “suck down” event?** The inflow cannula drawing blood from the left cannula can catch part of the wall of the left ventricle. The wall can suck into the intake. This drops the cardiac output. This can happen due to hypovolemia and cannula malposition. Cannula malposition may occur over time. The cure for this is to give volume early on and evaluate with ultrasound. The LVAD may detect this and slow down to free up the free wall. However, it may recur.
What if you see atrial fibrillation or ventricular tachycardia? Do you need to treat it? If the patient has left ventricular tachycardia, the LVAD can handle it. However, don’t forget about the right ventricle. If you lose the filling from the RV due to arrhythmia, you won’t fill the LVAD effectively. You want to treat LVAD patients just the same as any patient and regain the native rhythm.

Can you electrically cardiovert the patient? Don’t worry about the LVAD. It can handle it. If you need to shock the patient, you should do it. Try to place the pads away from the LVAD. It may be difficult to determine the location of the LVAD as you can’t always palpate it. Imaging can help determine where the LVAD is.

What do you do if you see ST elevation on the ECG in an LVAD patient? There are different practices in the literature.

- If the patient has ST elevation in the left ventricle and you are worried about infarction, some call the cath lab. Some try to recover as much myocardium as possible. It never hurts to call the cath team and involve them.
- You need to be really careful about the right ventricle. If you infarct the RV, you are losing the filling to the LVAD. Treat them aggressively.

What do you do if the patient has melena?

- Patients with LVADs are higher risk for gastrointestinal hemorrhage than the regular population because they are taking anti-coagulation and antiplatelet agents. These patients also have an acquired von Willebrand disease. The von Willebrand factor is a large molecule and gets broken up by the LVAD. They also have acquired AV malformations throughout the GI tract.
- Resuscitate as usual. Your goal MAP is 70 mmHg. If they are not actively bleeding, the hemoglobin cutoff is 7.
- If you are able to wait, try to use cross-matched blood to reduce their exposure to antibodies. These patients may be candidates for heart transplant in the future. If you need to give blood quickly do it.
- Reversal of anticoagulation in these patients is tricky. You can give them platelets. You can give them DDAVP. Most centers advocate against the use of prothrombin complex concentrate (PCC). Full reversal puts these patients at much higher risk of pump thrombosis which is difficult to recover from. Give vitamin K and FFP. Talk with the LVAD team about reversal with PCC.

CASE
A 57 year old female with an LVAD has cardiac arrest in the emergency department.

- CPR is not a benign maneuver in these patients. We need to be sure the patient is truly in arrest before initiating CPR.
- Determine if the LVAD is working. Auscultate the chest. There will not be a pulse but there should be a hum.
- If there is a hum, find out the mean arterial pressure. You can do this with the manual blood pressure cuff.
- Look with ultrasound and see if the RV and LV are working.
- Look for error messages on the controller and make sure all the connections are in place. Is the battery is charged? Is the controller hooked up to the drive line?
- The device manufacturers recommend that you don’t do chest compressions due to concerns about cannula dislodgement. However, if the patient is already dead, they can’t get deader. Doing CPR will be beneficial. You have to do something. Zack Shinar did a study involving 8 patients with LVADs who received CPR. None of the patients who died had dislodgement of their cannula found on autopsy. Four of the patients who survived had neurologic recovery.
  - Shinar, Z et al. Chest compressions may be safe in arresting patients with left ventricular assist devices (LVADs). Resuscitation. 2014 May;85(5):702-4. PMID: 24472494
- How do you do CPR in a LVAD patient? This is controversial. Most recommend standard closed chest compressions. Some surgeons recommend abdominal compressions. These are not as good as closed chest compressions but protect the cannulas. Find your local LVAD team and ask what practice they prefer so everyone is on the same page.