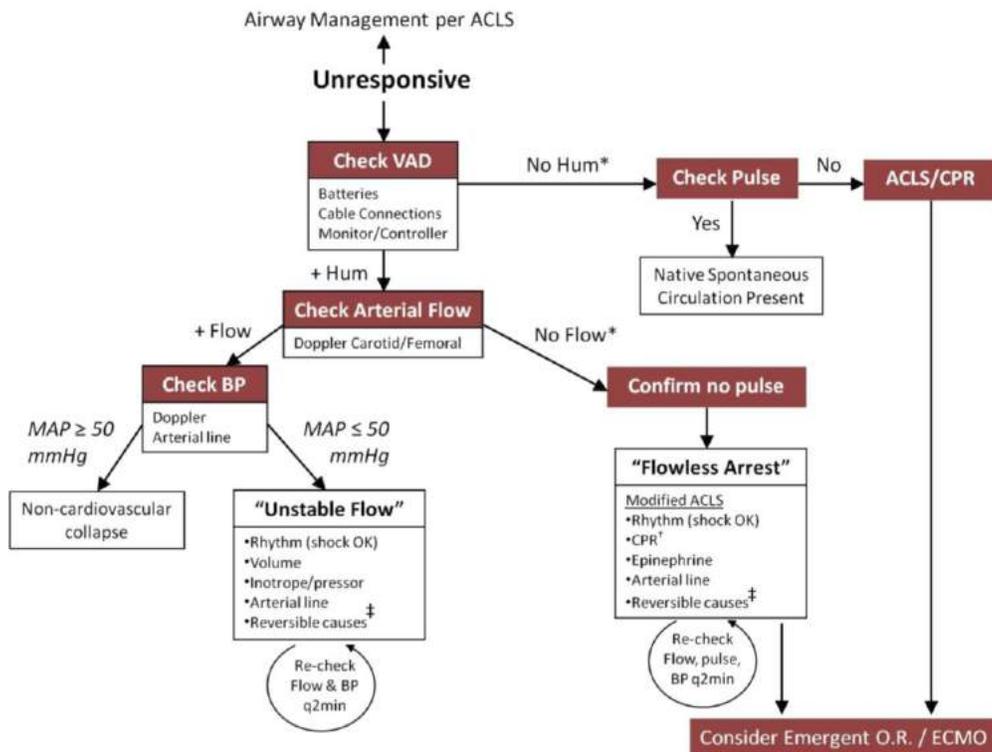


ACS Rotation Guide

ACLS in LVAD patients: Review it, learn it, DO IT!



Garg, Drazner. J Cardiac Fail 2014.

Note: for all LVAD codes, call attending immediately. They may decide to place the patient on ECMO.

When coding patients we are primary on: No declaring a patient dead unless it has been discussed prior by the primary team and known. Often there are rescue therapies or ECMO that may be deployed. If a Code Blue occurs, call the attending directly. Only call the fellow if unable to reach attending as calling the fellow first will delay important decision making.

LVAD basics:

- These patients may or may not have a pulse. If they do not have a pulse, we use MAP (mean arterial pressure) with a goal MAP of 70-80 mmHg. This can be measured with a pulse pressure cuff and doppler US.
- There are 3 types of LVADs that are used right now: Heart Mate II, Heart Mate III, and Heart Ware. Pump speed (RPMs) and pump power (watts) are the most important and only measured variables. Everything else is calculated
- LVAD flow is derived from pump speed (increased speed = increased flow, decreased speed = decreased flow). This is displayed as RPMs (revolutions per minute). This is set and defined by the attendings and the LVAD team. You do not change this setting.

- Pump power (watts) is the amount of energy required to maintain a set pump speed. Think of it like horsepower for an engine to maintain speed on the highway. This is directly measured.
- Pump flow is calculated and not directly measured. It has several variables it uses to calculate the flow and this can be prone to error, especially if LVAD is alarming.

You will always need to check the LVAD monitor (on admission, and then at least daily) for any PI (pulsatility index) events and/or alarms (low flow events, high powers, etc). It is not difficult to do and your fellow or resident can show you how to do so.

PI is a measurement of flow pulse through the pump. PI is determined on contractility, preload, and afterload. It is a calculated variable and also prone to error. A PI event is defined as a 45% drop in PI.

Possible causes include:

- Pump speed
- Obstruction
- Myocardial recovery
- Dehydration, RV failure, arrhythmias
- High MAPs or hypertension
- Suction event (only in the Heart Mate II/III)

Blood Pressure: The ideal MAP in LVAD patients is 65-80 mm Hg (MAPs >90 are correlated with increased risk of stroke).

How to measure BP in patients with LVADs:

- 1) External blood pressure cuff (if the patient has a pulse – not every patient does!)
- 2) Doppler – Place a manual BP cuff on your patient’s arm, and place the Doppler US probe over the brachial artery. Inflate cuff, then slowly deflate it. When you can hear the Doppler waveform, that pressure reading is the MAP.

Suggested tips when admitting LVAD patients:

- On admission, check to see if your LVAD patient has a pulse (not everyone does!). Document this carefully in your H&P, as you will refer back to this during the admission. A change in pulse presence is important to follow up on!
- Suggested admission labs:
 - NT-proBNP
 - INR (all patients on LVADs will be on anticoagulation; check last clinic note for their specific INR goal, but generally 2 – 2.5 unless they have had bleeding complications. If INR is subtherapeutic, they will need to be on a heparin drip until they are therapeutic.)
 - LDH and sometimes haptoglobin (helps assess for LVAD thrombus), possibly plasma free Hb as well if suspicious for pump thrombus
- At the time of admission, you will also need to put in LVAD orders (LVAD parameters are included in the last clinic note, and these parameters should be discussed during rounds).

LVAD alarms:

HeartMate II[®]
Left Ventricular Assist System

Pump Parameter Overview

There are four parameters monitored on the HeartMate II: **Speed, Flow, Power and Pulsatility Index**. No single parameter is a surrogate for monitoring a patient's clinical status. It is important to consider trends. Each patient's values are specific to their pump.

SPEED

- Speed can only be changed using the system monitor
 - If speed is turned up, more blood is pulled from the LV = ↓LV chamber size
 - If speed is turned down, less blood pulled from the LV = ↑LV chamber size
- The System Monitor displays the pump speed in revolutions per minute (rpm). This value matches the actual speed within ±100 rpm under normal conditions.

POWER

- Device power is a direct measurement of pump motor voltage and current. Changes in pump speed, flow, or physiological demand can affect pump power

Look at trends over days (patient daily log) Report trend increases & decreases of 2.0 Watts Report double digit power demands ≥10.0 watts

FLOW

- Flow is an estimate that is derived from a calculation of fixed speed and power
- Flow and power have a linear relationship: ↑Power = ↑Flow estimate ↓Power = ↓Flow estimate
 - If the flow estimate falls outside the expected operational range or acceptable linear region, "+++ " or "-.-" is displayed. This prevents the display of inaccurate flow information
 - If flow falls below 2.5 L/min, the HM II will alarm "low flow"
- Afterload Sensitive:** If afterload (blood pressure) is high, the pump will not increase speed to overcome the high outflow pressure. Because power demand is not increased, the displayed flow read out may not change or, potentially decrease, even though the true flow out of the pump is hindered by the high aortic pressure
- At any given speed, increased blood pressure will decrease flow

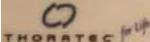
PULSATILITY INDEX

- Pulsatility Index (PI) is the left ventricle's (LV) pulsatile contribution to the pump:
 - LV full → greater stretch → greater contractility = ↑Pulsatility Index
 - LV empty → less stretch → little contractility = ↓Pulsatility Index
- PI as it relates to changes in patient's status:
 - Indicative of changes in volume status due to altered preload
 - Indicative of changes to the natural heart's contraction
- PI as it relates to changes in pump speed:
 - As pump speed is increased, the PI goes down
 - As pump speed is decreased, the PI goes up

PI EVENT

- A PI event occurs when there is a 45% + or - change from the previous 1.5 second running average. Possible causes of events:

Suction event: the inflow cannula is obstructed	Dehydration, bleeding, increased diuretic dosage	Arrhythmia, Vasovagal response	Right heart failure Increased PA pressure
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- If a PI event is detected, the pump speed will automatically reduce to the low speed limit and then gradually ramps back up at 100rpm/sec to the fixed speed

Clinical Considerations			
CONT. FLOW PUMP Continuously unloads left ventricle, narrowing pulse pressure	VITALS Blood Pressure: Manual cuff with a doppler <input type="checkbox"/> Locate brachial or radial pulse with Doppler <input type="checkbox"/> Inflate BP cuff. Slowly release at 2mmHg per second <input type="checkbox"/> First sound heard is "return to flow". Document this number as the MAP <input type="checkbox"/> MAP goal: 70 – 90mmHg Pulse: May be thready or absent Oxygen Saturations: Unable to obtain due to poor capillary bed pulsatility	EKG Pump stops out affect the EKG	
ACLS/CPR ACLS per protocol – Defibrillation, cardioversion, external pacing okay – Do not place pads over the implanted HeartMate II LVAD or implanted ICD – Contact implanting center to discuss CPR guidelines	PUMP ASSMT Assess if pump is running: – Auscultate over the left upper quadrant to assess if pump is running – Report unusual sounds	INSPECT EQUIP – When changing power sources, inspect pins in the connectors of controller power leads, patient cable, and battery clips – Any issues with System Controller Operation	DRIVELINE Report any signs of infection including increased WBC or + cultures – Sterile dressing change per implant center protocol – Ask care provider if concerns with exit site – Review frequency of site care Report any tears or separations in the silicone on driveline Ensure patient is using an anchoring system to prevent tugging at exit site
INR Goal: 2.0 to 2.5 INR goal will vary for each patient. Contact implanting center for patient specific INR goal	MONITOR REVIEW & DOCUMENTATION Clinical Screen..... Review and Record: Speed, Flow, PI, Power Settings Screen..... Review and Record: Fixed Speed, Low Speed Limit Alarms Screen..... Review and Record: Active Alarms History Screen..... Review Event Log Document the serial number of the system controller in use	EMERGENCY BAG Patient should always carry emergency bag with backup controller, spare batteries and clips, and implanting center contact information	
PATIENT QUESTIONS – Any concerns with pump function? – Changes in how pump feels or sounds? – Any alarms? – Trauma to driveline site? – Concerns with equipment? – Decreased battery life?	– Feelings of heart failure returning? – Any bloody stool or nosebleeds? – Is urine dark in color? – Any weight gain or trouble breathing? – Any lightheadedness or dizziness? – Any returning symptoms of heart failure?	DAILY LOG Review and assess for trends	
 Thoratec Corporation, 6035 Stoneridge Drive, Pleasanton, CA 94588 1-925-847-8600 1-800-528-2577 www.thoratec.com Thoratec, HeartMate II and the Thoratec logo are registered trademarks of Thoratec Corporation. © 2014 Thoratec Corporation. All right reserved. 110128.B 04/2014			

Heart Transplant patients:

- All AM labs should be timed for 0800 daily, do not use AM prerounds when ordering labs.
- Immunosuppressive trough levels (order for 8 AM; patients take their immunosuppression in-house at 9 AM and 9 PM – troughs should be collected 1 hour prior to the next dose; adjust accordingly if patients take IS at other times)
 - Do not adjust their immunosuppression without talking to the fellow/attending.
- Immunosuppression regimens usually include a calcineurin inhibitor (cyclosporine or tacrolimus), an anti-metabolite (azathioprine or mycophenolate), steroids (particularly in the first year) and occasional uses of an mTOR (sirolimus, everolimus) or methotrexate (previous rejection).

- If the patient is unable to tolerate PO or GI absorption is questionable, the immunosuppression regimen drugs should be converted to IV. This needs to be discussed with the attending and usually the pharmacist.
- **NEVER** hold immunosuppression regardless of any infection or clinical situation. Infections can trigger acute rejection. Immunosuppression goals may be adjusted, but only after talking to fellow and/or attending.
- Signs of rejection: new heart failure (S3 on exam or signs of volume overload), tachyarrhythmias, bradycardias, decreased voltage on EKG, hypotension. This is an emergency and if you have concerns, you must call the fellow.
- For suspected transplant rejection, order urgent TTE (if overnight, then you will have to page the on-call cardiology fellow to have the on-call sonographer come in), CMV PCR, EBV PCR. Attending will guide you on steroids, IVIG, when to biopsy.
- For patients who are awaiting transplant, they are ours until surgery. At the time of OR, the CHF fellow will place the orders for immunosuppression. Immediately after transplant, they CVTS becomes the primary team (we still follow along and see daily as a consult); we resume being primary once the patient is stable after surgery and is transferred to general care. We are responsible for setting up their discharge and post-discharge follow-up.

Special things to be aware of:

- In patients s/p heart transplant, DO NOT use adenosine to treat tachyarrhythmias. Their new hearts are denervated and you can precipitate severe bradyarrhythmias or heart block...and this can be fatal.
- Always check neck veins, report JVP (cmH₂O), and HJR (hepatojugular reflux, not reflex). If a patient gets a RHC you should know the numbers, and be familiar with the interpretation; you will likely discuss these during rounds and make decisions based on them. Often times patients get endomyocardial biopsies during RHCs, so you will need to follow up the pathology results.
- Several ICU patients will have Swan-Ganz catheters in place. For these patients, a daily CXR should be ordered to make sure the catheter hasn't moved. On rounds, you will review the CXR and discuss trends on the parameters (RA pressure, PA pressure, and cardiac index. Only the fellow/attending is allowed to wedge the PA catheter (there is a risk of pulmonary infarction).
- Many patients are transferred from outside hospitals for advanced therapy evaluation. Often, they are not well informed about what the process will entail. They may ask "when do I get my new heart?", etc. I find the best way to deflect is something like, "Transplant and LVAD are the right choice for some of our patients, but are not the right choice for all of them. We need to take the next few days to learn about you with labs, tests and consults. Likewise, you get to learn about possible options. Eventually we discuss everything with a committee to see what options are best suited to you."
- For patients who receive a heart transplant. You cannot tell them **anything** about the donor. No location, age, mechanism of death, etc. Patients are very savvy and have been able to correctly guess about the situation surrounding their donor. This can lead to incredible guilt on the transplant recipient's part with profound mental health impacts. Only attendings can disclose very specific information. You can tell them, "we found a great heart for you." After one year the patients and donor families can connect via UNOS (the only acceptable way) should they both choose.

- Regarding patients with a potential offer. Please only let attendings or fellows tell patients about offers. They often will get an offer that we will pass on or turn down for various reasons. Occasionally patients will have a dry run (an accepted offer we turn down upon visual inspection of the donor organ). As you can imagine this can be very stressful for patients and families.
- In general, our service has very long and extensive relationship with our patients (>20 years on occasion). Our attendings and the families know each other incredibly well and this is reflected in the care they provide.
- At times, these are profoundly stressful situations for patients and families. Please give them some grace if a conversation does not go as planned. We often encounter challenging situations especially when they are declined for LVAD or heart transplant at our center. Bring up these discussions with the team when you have questions or concerns. The ethics of transplant is an important learning aspect of this rotation.
- As above tacrolimus levels must be drawn at 0800. For patients on IV tacrolimus infusions, tacrolimus levels must be a peripheral stick. Tacrolimus “sticks” to the inside of catheter and lines leading to very high falsely elevated levels.

Discharges:

- CHF-related admissions are seen within a week of discharge usually (there is a HF discharge coordinator who helps with this, Anne McCormack)
- Other discharge follow-up timelines are up to the team, you will need to let the coordinator know when the patient needs to be seen.
- The NPs can help find the people you need to contact
- Message the patient's CHF clinic coordinator to assist with follow-up arrangements (labs, appts, etc...)
 - For transplant patients, there is a link at the bottom of EPIC that says transplant and has all their coordinator info
 - Otherwise you can look at their encounters and see who their coordinator is based on phone calls, etc.
- For INR/Pharm issues there are 2 CHF pharmacists you may also want to CC on the discharge summary
- LVAD coordinators and clinic schedulers are on sheets of paper for reference in the rounding room

Order Sets:

Admission Orders:

- Use the CHF orderset.
- Pre-transplant work-up: If a patient is deemed eligible for advanced HF therapies (LVAD or transplant), a multi-disciplinary work-up will be started. Use the “cardiac transplant candidate evaluation” orderset, several services (i.e. transplant nephrology, neurology, transplant ID, GI, etc) will be consulted, and the appropriate lab work will be ordered.

Notes:

Please see additional document on useful dot phrases.