

UC Irvine

Journal of Education and Teaching in Emergency Medicine

Title

Left Ventricular Assist Devices

Permalink

<https://escholarship.org/uc/item/3zc3z4gn>

Journal

Journal of Education and Teaching in Emergency Medicine, 2(2)

Authors

Narajeenron, Khuansiri
Hoonpongsimanot, Wirachin Ying
Boysen Osborn, Megan

Publication Date

2017

DOI

10.5070/M522034556

Copyright Information

Copyright 2017 by the author(s). This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

Peer reviewed

Left Ventricular Assist Devices

Khuansiri Narajeenron, MD, MSc^{*^}, Wirachin Ying Hoonpongsimanot, MD, MS[^] and Megan Boysen Osborn, MD, MHPE[^]

^{*}Chulalongkorn University and the Thai Red Cross Society, Department of Emergency Medicine, Bangkok, Thailand

[^]University of California, Irvine, Department of Emergency Medicine, Orange, CA

Correspondence should be addressed to Megan Boysen Osborn, MD, MHPE at mbo@uci.edu

Submitted: March 1, 2017; Accepted: March 30, 2017; Electronically Published: April 15, 2017; <https://doi.org/10.21980/J8JP4Z>

Copyright: © 2017 Narajeenron, et al. This is an open access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY 4.0) License.

See: <http://creativecommons.org/licenses/by/4.0/>

ABSTRACT:

Audience: The audience for this classic team-based learning (cTBL) session is emergency medicine residents, faculty, and students; although this topic is applicable to internal medicine and family medicine residents.

Introduction: A left ventricular assist device (LVAD) is a mechanical circulatory support device that can be placed in critically-ill patients who have poor left ventricular function. After LVAD implantation, patients have improved quality of life.¹ The number of LVAD patients worldwide continues to rise. Left-ventricular assist device patients may present to the emergency department (ED) with severe, life-threatening conditions. It is essential that emergency physicians have a good understanding of LVADs and their complications.

Objectives: Upon completion of this cTBL module, the learner will be able to: 1) properly assess LVAD patients' circulatory status; 2) appropriately resuscitate LVAD patients; 3) identify common LVAD complications; 4) evaluate and appropriately manage patients with LVAD malfunctions.

Method: The method for this didactic session is cTBL.

Topics: Left ventricular assist device, LVAD, TBL, LVAD complication, LVAD malfunction, emergency medicine, cardiology.



USER GUIDE

List of Resources:

Abstract	1
User Guide	2
Learner Materials	4
iRAT	4
gRAT Picture	7
gRAT	8
GAE	11
Post Test	13
Instructor Materials	15
RAT Key	16
GAE Key	18
Post Test Key	20

Learner Audience:

Medical students, interns, junior residents, senior residents, faculty

Time Required for Implementation:

Instructor Preparation: 60 minutes

Learner Responsible Content: 30 minutes

In Class Time: 90 minutes

Recommended Number of Learners per Instructor:

This module has been successful in a session of 60 learners, but the recommended number of learners is 20-40

Topics:

LVAD, left ventricular assist device, TBL, LVAD complication, LVAD malfunction, emergency medicine, cardiology.

Objectives:

Upon completion of this cTBL module, the learners will be able to:

1. List all procedures that can be used to assess LVAD patients' circulatory status (properly assess LVAD patients' circulatory status)
2. Know the indication for chest compression and using a defibrillator to resuscitate LVAD patient (appropriately resuscitate LVAD patients)
3. Identify the most common LVAD complications
4. Evaluate and appropriately manage patients with LVAD malfunctions

Linked objectives and methods:

The first pre-reading (ALiEM PV card) discusses common LVAD complications and their management (objectives 3 & 4) and echocardiographic findings during each complication (objective 1). The second pre-reading (EMCrit Blog) also covers common complications and management (objectives 3 & 4) and discusses the indications for chest compression and

defibrillation (objective 2). Learners will demonstrate that they can assess circulation by answering the first and second questions in the individual and group readiness assessment tests (iRAT and gRATs). The iRAT/gRAT questions 3 and 5 discuss indications for CPR and defibrillation on an LVAD patient. The fourth and sixth iRAT/gRAT questions cover common complications and how to assess circulation. Learners apply the knowledge during the group application exercise by developing a differential diagnosis for an unstable LVAD patient, determining how they would evaluate and manage the patient. Lastly, learners are assessed in a post-test—done via paper or

Kahoot: www.getkahoot.com

<https://play.kahoot.it/#/?quizId=d017dc2c-02b2-45f1-a73b-a0bd122e360a>

Recommended pre-reading for instructor:

- Stadlberger N. PV Card: LVAD Complications. ALiEM. <https://www.aliem.com/2016/pv-card-lvad-complications>. Published November 23, 2016. Accessed March 2, 2017.
- Weingart S. Left Ventricular Assist Devices (LVADS). EMCrit. <https://emcrit.org/wee/left-ventricular-assist-devices-lvads-2>. Published July 8, 2012. Accessed March 2, 2017.

Learner responsible content (LRC):

- Stadlberger N. PV Card: LVAD Complications. ALiEM. <https://www.aliem.com/2016/pv-card-lvad-complications>. Published November 23, 2016. Accessed March 2, 2017.
- Weingart S. Left Ventricular Assist Devices (LVADS). EMCrit. <https://emcrit.org/wee/left-ventricular-assist-devices-lvads-2>. Published July 8, 2012. Accessed March 2, 2017.

Results and tips for successful implementation:

This LVAD TBL was piloted on a group of nine learners. On the post-test, five learners received scores of 80% or higher. Two of the learners with scores below 80% were medical students and two were interns. While only two learners evaluated the session, both felt that the session was highly relevant (4/4 on Likert scale: Not applicable (1), somewhat relevant (2), mostly relevant (3), and highly relevant (4)). Learners were observed to be highly engaged during the session, although anecdotally, the learners who had completed the pre-reading seemed more engaged than those who had not. Therefore, it is recommended that the instructor encourages the learners to complete the pre-reading. As a result, we also revised the PowerPoint to be more comprehensive than the original.

The LVAD TBL was subsequently utilized in a group of 63 learners at a national emergency medicine conference. The



USER GUIDE

delivery was rated as: excellent (n=40, 63%), very good (n=16, 25%), good (n=7, 11%), fair (n=0, 0%), poor (n=0, 0%). The content was rated as excellent (n=43, 68%), very good (n=12, 19%), good (n=7, 11%), fair (n=1, 2%), poor (n=0, 0%). The post-test results are not available for this group of learners.

Before the session, the instructor should prepare the following:

1. Send the pre-reading to learners one week in advance, with reminders two days before the session.
2. Copy one iRAT per learner.
3. Copy one gRAT per every four learners.
4. Purchase “scratch-off stickers” in order to make the gRAT. Cut and place scratch-off stickers over the letter options as shown with the gRAT.
5. Copy one group application exercise per every four learners.
6. The instructor can make one copy of the post-test per each learner or deliver the post-test via Kahoot:
 - a. www.getkahoot.com
 - b. <https://play.kahoot.it/#/?quizId=d017dc2c-02b2-45f1-a73b-a0bd122e360a>

The session is best run with the following timeline:

1. Pre-reading: Send to learners one week in advance
2. Lecture: 5-10 minutes
3. iRAT: 5-10 minutes
4. gRAT: 10 minutes
5. Group Application Exercise: 30 minutes
6. Discussion of Group Application Exercise Answers: 20 minutes
7. Post-Test: 10 minutes

Content:

- iRAT
- gRAT
- GAE
- Post Test
- RAT Key
- GAE Key
- Post Test Key
- LVAD Lecture

References:

1. Modica M, Ferrantini M, Torri A, Oliva F, Martinelli L, De Maria R, et al. Quality of life and emotional distress early after left ventricular assist device implant: A mixed-method study. *Artif Organs*. 2014;39(3):220-227. doi: 10.1111/aor.12362
2. Stadlberger N. PV Card: LVAD Complications. ALiEM. <https://www.aliem.com/2016/pv-card-lvad-complications>. Published November 23, 2016. Accessed March 2, 2017.

3. Weingart S. Left Ventricular Assist Devices (LVADS). EMCrit. <https://emcrit.org/wee/left-ventricular-assist-devices-lvads-2>. Published on July 8, 2012. Accessed on March 2, 2017.
4. Slaughter MS, Rogers JG, Milano CA, Russell SD, Conte JV, Feldman D, et al. Advanced heart failure treated with continuous-flow left ventricular assist device. *N Engl J Med*. 2009;361(23):2241-2251. doi: 10.1056/NEJMoa0909938
5. Feldman D, Pamboukian SV, Teuteberg JJ, Birks E, Lietz K, Moore SA, et al. The 2013 International Society for Heart and Lung Transplantation Guidelines for mechanical circulatory support: executive summary 2013;32(2):157-187. doi: 10.1016/j.healun.2012.09.013
6. Slaughter MS. Hematologic effects of continuous flow left ventricular assist devices. *J Cardiovasc Transl Res*. 2010;3(6):618-624. doi: 10.1007/s12265-010-9222-6
7. Baghai M, Heilmann C, Beversdorf F, Nakamura L, Geisen U, Olschewski M, et al. Platelet dysfunction and acquired von Willebrand syndrome in patients with left ventricular assist devices. *Eur J Cardiothorac Surg*. 2015;48(3):421-427. doi: 10.1093/ejcts/ezu510

Suggestions for further reading:

- See references 2 and 3
- Figures 1 and 2 (p.167 and 170) from reference 5.
- Partyka C, Taylor B. Review article: ventricular assist devices in the emergency department. *Emerg Med Australas*. 2014;26(2):104-112. doi: 10.1111/1742-6723.12171
- Stainback RF, Estep JD, Agler DA. Echocardiography in the management of patients with left ventricular assist devices: recommendations from the American Society of Echocardiography. *J Am Soc Echocardiogr*. 2015;28(8):884, table 4b. doi: 10.1016/j.echo.2015.05.008
- Pelletier K. HeartMate II LVAD controller alarms. <https://www.youtube.com/watch?v=7-Oypu1YCPw>. Published August 10, 2016. Accessed March 2, 2017.
- Green K. Heartware LVAD. <https://www.youtube.com/watch?v=-FHNeE-ifmY&feature=youtu.be>. Published October 13, 2013. Accessed March 2, 2017.



Left Ventricular Assist Device individual Readiness Assessment Test (iRAT)

1. Which of the following is an INCORRECT method of assessing circulation in an LVAD patient?
 - a. Using an arterial line to obtain mean arterial blood pressure (MAP)
 - b. Auscultate and palpate the precordium, listening and feeling for a hum or vibration
 - c. Checking a patient's radial pulse
 - d. Checking tissue perfusion (capillary refill, mental status, urine output, skin signs)
 - e. Using a manual blood pressure cuff with doppler to measure MAP
 - f. Using a manual blood pressure cuff with doppler to measure systolic and diastolic blood pressure (SBP and DBP)
 - g. A&E
 - h. C&F

2. What is an acceptable MAP in a patient with an LVAD?
 - a. <60 mmHg
 - b. 60-80 mmHg
 - c. 80-110mm Hg
 - d. >110 mmHg

3. Which of the following is an indication for cardiopulmonary resuscitation (CPR) in a patient with an LVAD?
 - a. Absent pulses
 - b. Loss of consciousness
 - c. MAP < 60 mm Hg
 - d. MAP = 0 mm Hg and pump stopped
 - e. None of the above

4. A 65-year old LVAD patient presents with upper GI bleeding. Why is bleeding common in LVAD patients?



LEARNER MATERIALS

- a. Oral anticoagulant and anti-platelet use
 - b. Acquired Von-Willebrand's Disease
 - c. Increased risk of AVM due to chronic low pulse pressure
 - d. Platelet dysfunction
 - e. All of the above
5. You are monitoring an LVAD patient, who starts to become altered. Mean arterial pressure is measured as 50 mmHg. The patient's capillary refill is 4 seconds. The controller alarm is flashing "low flow." The cardiac monitor is **shown below**. What is your next step management?



Image: By Glenlarsen - Own work, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=51194100>

- a. Check for battery power and line connection and contact the patient's LVAD company.
- b. Check electrolytes (potassium, magnesium) and start amiodarone
- c. Synchronized cardioversion at 100 Joules
- d. Perform a 12 lead EKG and consult EP cardiologist to do a catheter ablation
- e. Defibrillation at 200 Joules



LEARNER MATERIALS

6. Your LVAD patient develops hypotension and the controller alarm flashes “low flow.” Match the following echo finding with their associated disease entities: Put each number in the appropriate box in the table below (more than one number can be in each box). (RV: right ventricle, LV: left ventricle)

1. Pump not working or pump thrombosis
2. Significant aortic regurgitation (AR)
3. Hypovolemia/Bleeding
4. Massive PE
5. Right ventricular failure (MI)
6. Cardiac tamponade
7. Left Ventricular suction event

	RV size: Decreased	RV size: No change	RV size: Increased
LV size: Decreased			
LV size: No change			
LV size: Increased			

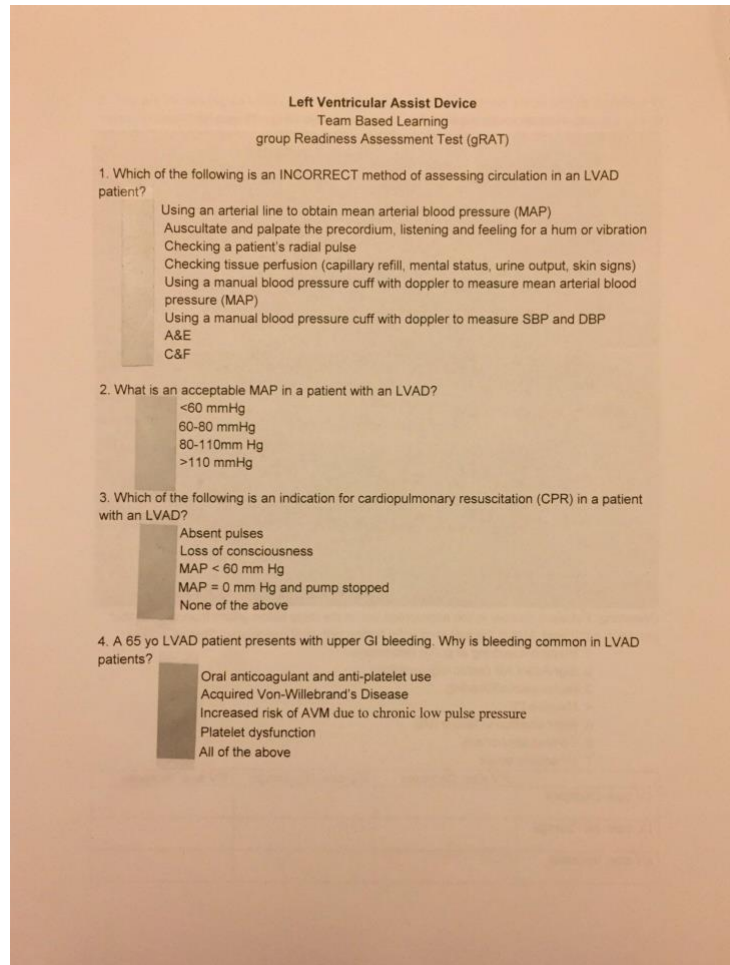


LEARNER MATERIALS

group Readiness Assessment Test (gRAT):

We used: 2"x1" Silver Rectangle Scratch Off Labels Sticker - Pack of 500 from www.amazon.com

See picture of how the scratch off stickers are placed gRAT below:



For question 6, scratch off stickers should be placed over each of the 9 boxes (even the empty ones)



LEARNER MATERIALS

Left Ventricular Assist Device group Readiness Assessment Test (gRAT)

1. Which of the following is an INCORRECT method of assessing circulation in an LVAD patient?
 - a. Using an arterial line to obtain mean arterial blood pressure (MAP)
 - b. Auscultate and palpate the precordium, listening and feeling for a hum or vibration
 - c. Checking a patient's radial pulse
 - d. Checking tissue perfusion (capillary refill, mental status, urine output, skin signs)
 - e. Using a manual blood pressure cuff with doppler to measure MAP
 - f. Using a manual blood pressure cuff with doppler to measure systolic and diastolic blood pressure (SBP and DBP)
 - g. A&E
 - ♥ C&F

2. What is an acceptable MAP in a patient with an LVAD?
 - a. <60 mmHg
 - ♥ 60-80 mmHg
 - c. 80-110mm Hg
 - d. >110 mmHg

3. Which of the following is an indication for cardiopulmonary resuscitation (CPR) in a patient with an LVAD?
 - a. Absent pulses
 - b. Loss of consciousness
 - c. MAP < 60 mm Hg
 - ♥ MAP = 0 mm Hg and pump stopped
 - e. None of the above

4. A 65-year old LVAD patient presents with upper GI bleeding. Why is bleeding common in LVAD patients?



LEARNER MATERIALS

- a. Oral anticoagulant and anti-platelet use
 - b. Acquired Von-Willebrand's Disease
 - c. Increased risk of AVM due to chronic low pulse pressure
 - d. Platelet dysfunction
 - ♥ All of the above
5. You are monitoring an LVAD patient, who starts to become altered. Mean arterial pressure is measured as 50 mmHg. The patient's capillary refill is 4 seconds. The controller alarm is flashing "low flow." The cardiac monitor is **shown below**. What is your next step management?



Image: By Glenlarsen - Own work, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=51194100>

- a. Check for battery power and line connection and contact the patient's LVAD company.
- b. Check electrolytes (potassium, magnesium) and start amiodarone
- ♥ Synchronized cardioversion at 100 Joules
- d. Perform a 12 lead EKG and consult EP cardiologist to do a catheter ablation
- e. Defibrillation at 200 Joules



LEARNER MATERIALS

6. Your LVAD patient develops hypotension and the controller alarm flashes “low flow.” Match the following echo finding with their associated disease entities: Put each number in the appropriate box in the table below (more than one number can be in each box). (RV: right ventricle, LV: left ventricle)

1. Pump not working or pump thrombosis
2. Significant aortic regurgitation (AR)
3. Hypovolemia/Bleeding
4. Massive PE
5. Right ventricular failure (MI)
6. Cardiac tamponade
7. Left ventricular suction event

	RV size: Decreased	RV size: No change	RV size: Increased
LV size: Decreased	3, 6, 7	3, 7	4, 5
LV size: No change			4, 5
LV size: Increased		1, 2	



LEARNER MATERIALS

Left Ventricular Assist Device Group Application Exercise (GAE)

Case:

A 50-year old female with history of diabetes mellitus (DM) and ischemic cardiomyopathy status post LVAD (Heartmate II) for bridge to heart transplant two week ago presents after collapsing at her routine follow up appointment, 5 minutes prior to arrival.

1. What is your differential diagnosis?
2. How will you assess her perfusion after you manage her airway and breathing?
3. From your answer to #2, you decide that the LVAD is not working. What are your next steps?
4. You fix the issue in #3, and feel the LVAD is working, but the alarm is going off and the MAP is <60. What are your next steps?
5. The machine is hot and the echocardiogram shows normal RV size but a dilated LV. What is the possible cause?
6. How to investigate and manage the diagnosis in #5?



LEARNER MATERIALS

7. What is the definitive therapy for pump failure?

8. What is the definitive therapy for significant aortic regurgitation?



LEARNER MATERIALS

Left Ventricular Assist Device Post Test

This can also be played as a Kahoot:

<https://play.kahoot.it/#/?quizId=d017dc2c-02b2-45f1-a73b-a0bd122e360a>

1. In LVAD patient, which parts of the advanced cardiac life support (ACLS) algorithm should you try to avoid?
 - a. Defibrillation and cardioversion
 - b. External pacing
 - c. ETCO₂
 - d. Chest compressions
2. A patient presents with the following; which of the following is true?



Image courtesy: <http://lvad-inc.blogspot.com/2012/01/human-body-and-its-miracle-of-healing.html>

- a. Fungal cultures should be sent
- b. *P. aeruginosa* is the most common organism
- c. The drive line should be removed
- d. This is the most common cause of death in LVAD patients



LEARNER MATERIALS

3. For life threatening bleeding in an LVAD patient (massive GI bleeding or intracranial hemorrhage), which one is correct?
 - a. Blood transfusion keep hemoglobin >10g/dL
 - b. Actively reverse anticoagulant with vitamin K, fresh frozen plasma, and/or prothrombin complex concentrate (PCC)
 - c. Hold anticoagulant
 - d. Monitor patients and device parameters
 - e. All of the above

4. Which of the following supports the diagnosis pump thrombosis in an LVAD patient?
 - a. High power > 10 Watts
 - b. Cool device
 - c. Enlarged LV and elevated peak outflow
 - d. Low-flow alarm
 - e. A, C, D
 - f. All of the above

5. What is treatment in stable sustained monomorphic ventricular tachycardia (VT) arrhythmia in LVAD patient?
 - a. Chest compressions
 - b. Defibrillation at 200J
 - c. Epinephrine
 - d. IV fluids if there is a suction event



INSTRUCTOR MATERIALS

Answer keys to all exercises with explanations, are on the following pages.

Learners: please do not proceed.



INSTRUCTOR MATERIALS

Left Ventricular Assist Device Readiness Assessment Test Answer Key (RAT Key)

1. Which of the following is an INCORRECT method of assessing circulation in an LVAD patient?

Answer: H: Continuous flow LVAD (CF-LVAD) devices are the most widely used LVAD devices.⁴ Patients, therefore, may have diminished or absent pulses. Similarly, because flow is not pulsatile, measuring systolic and diastolic blood pressures is not applicable.

2. What is an acceptable MAP in a patient with an LVAD?

Answer B. 60-80 mmHg

According to Feldman,⁵ patients with a CF-LVAD should have a mean blood pressure less than 80 mm Hg and greater than 60.

3. Which of the following is an indication for cardiopulmonary resuscitation (CPR) in a patient with an LVAD?

Answer D. MAP = 0 mm Hg and pump stopped is an indication for CPR. Fluid bolus and device optimization should be attempted in patients with a low MAP. Absent pulses are common in patients with continuous flow LVADs. Patients who are unconscious do not necessarily need CPR. Cardiopulmonary resuscitation puts patients at risk for device dislodgment and ventricular wall rupture.

4. A 65-year old LVAD patient presents with upper GI bleeding. Why is bleeding common in LVAD patients?

Answer E. All of the above: Patients with LVADs take oral anticoagulants and anti-platelet agents. They have acquired Von-Willebrand's disease from the shear stress of CF-LVADs that may cause proteolysis of von Willebrand's factor.^{6,7} Patients are also at risk of arteriovenous malformations due to chronic low pulse pressure.



INSTRUCTOR MATERIALS

5. You are monitoring an LVAD patient, who starts to become altered. Mean arterial pressure is measured as 50 mmHg. The patient’s capillary refill is 4 seconds. The controller alarm is flashing “low flow.” The cardiac monitor is **shown below**. What is your next step management?



Image: By Glenlarsen - Own work, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=51194100>

Answer: C: Synchronized cardioversion at 100 Joules. The patient is unstable and therefore not a candidate for IV anti-arrhythmics alone. The patient has a MAP of 50mmHg, so therefore can be cardioverted, rather than defibrillated.

6. Your LVAD patient develops hypotension and the controller alarm flashes “low flow.” Match the following echo finding with their associated disease entities: Put each number in the appropriate box in the table below (more than one number can be in each box).

	RV size: Decreased	RV size: No change	RV size: Increased
LV size: Decreased	3, 6, 7	3, 7	4, 5
LV size: No change			4, 5
LV size: Increased		1, 2	



INSTRUCTOR MATERIALS

Left Ventricular Assist Device Group Application Exercise Key (GAE Key)

Case:

A 50-year old female with history of diabetes mellitus (DM) and ischemic cardiomyopathy status post LVAD (Heartmate II) for bridge to heart transplant two week ago presents after collapsing at her routine follow up appointment, 5 minutes prior to arrival.

1. What is your differential diagnosis?

Acute stroke, intracranial hemorrhage, cardiac arrest, pump failure or thrombosis, cardiac tamponade, massive PE, dysrhythmia, hypoglycemia, severe active bleeding, pneumothorax, aortic dissection, sepsis, acidosis

2. How will you assess her perfusion after you manage her airway and breathing?

*-Listen for hum over precordium
-Feel vibration over precordium
-Doppler measurement of MAP
-Skin signs
-Assess mental status*

3. From your answer to #2, you decide that the LVAD is not working. What are your next steps?

*-Contact LVAD team coordinator
-Check batteries
-Plug in LVAD
-Check connections
-Make sure drive line is connected
-Check alarms, what are alarms saying?*



INSTRUCTOR MATERIALS

4. You fix the issue in #3, and feel the LVAD is working, but the alarm is going off and the MAP is <60mmHg. What are your next steps?
 - Echo, EKG, cardiac monitor, fluid bolus, IV access, labs, ABG
 - Check which alarms are going off (Is there low flow? Is the machine hot?)

5. The machine is hot and the echocardiogram shows normal RV size but a dilated LV. What is the possible cause?
 - Pump thrombosis, see table 4b in Stainback, et al⁶
 - Pump malfunction of mechanical component
 - Significant aortic regurgitation

6. How to investigate and manage the diagnosis in #5?
 - Consult cardiologist or contact LVAD team coordinator
 - Compare echo with previous echo
 - Clinical features associated with pump thrombosis include: intravascular hemolysis (hemoglobinuria, elevated creatinine, total bilirubin and elevated lactate dehydrogenase), high power alarm, hot device
 - Check prothrombin time (PT)/partial thromboplastin time (PTT)/international normalized ratio (INR), complete blood count, lactate dehydrogenase, liver function tests, creatinine, urinalysis
 - Goal INR depends on the device and ranges from 2.0 to 3.5.

7. What is the definitive therapy for pump failure?
 - Tissue plasminogen activator (TPA)
 - Heparin

8. What is the definitive therapy for significant aortic regurgitation?
 - Bioprosthetic valve
 - Heart transplant



INSTRUCTOR MATERIALS

Left Ventricular Assist Device Post Test Key

This can also be played as a Kahoot:

<https://play.kahoot.it/#/?quizId=d017dc2c-02b2-45f1-a73b-a0bd122e360a>

1. In LVAD patient, which parts of the advanced cardiac life support algorithm should you try to avoid?
 - a. Defibrillation and cardioversion
 - b. External pacing
 - c. ETCO₂
 - d. Chest compressions**

Explanation: CPR should generally be avoided, unless there is no perfusion (MAP=0) and device failure. CPR should be considered on a case by case basis. Remember that LVAD patients may not have detectable pulse or blood pressure (check MAP with Doppler).

2. A patient presents with the following; which of the following is true?



Image courtesy: <http://lvad-inc.blogspot.com/2012/01/human-body-and-its-miracle-of-healing.html>

- a. Fungal cultures should be sent**
- b. *P. aeruginosa* is the most common organism
- c. The drive line should be removed



INSTRUCTOR MATERIALS

- d. This is the most common cause of death in LVAD patients

Explanation: Infection is the 2nd common cause of death (second to cardiac failure). If suspected cannula or driven line infection, one should obtain a sample for routine bacterial and fungal cultures. Staphylococcus aureus is the most common cause of driveline infection.⁵

6. For life threatening bleeding in an LVAD patient (massive GI bleeding or intracranial hemorrhage), which one is correct?
- a. Blood transfusion keep hemoglobin >10
 - b. Actively reverse anticoagulant with vitamin K, fresh frozen plasma, and/or prothrombin complex concentrate (PCC)
 - c. Hold anticoagulant
 - d. Monitor patients and device parameter
 - e. **All of the above**

Explanation: According to Feldman, et al,⁵ patients with clinically significant bleeding and elevated INR should be reversed. In the absence of pump dysfunction, anti-coagulant and anti-platelets should be held until bleeding resolves. Patients should be transfused with goal hemoglobin > 10.

3. Which of the following supports the diagnosis pump thrombosis in an LVAD patient?
- a. High power > 10 Watts
 - b. Cool device
 - c. Enlarged LV and elevated peak outflow
 - d. Low-flow alarm
 - e. **A, C, D**
 - f. All of the above

Explanation: An echo will demonstrate increased size of the left ventricle, secondary to outflow obstruction; similarly the peak outflow cannula velocity will be elevated. The device will also show high power.



INSTRUCTOR MATERIALS

4. What is treatment in stable sustained monomorphic VT arrhythmia in LVAD patient?
- a. Chest compressions
 - b. Defibrillation at 200J
 - c. Epinephrine
 - d. IV fluids if there is a suction event**

Explanation: LVADs are preload dependent and afterload sensitive. Patients generally benefit from IV fluids, especially if there is a suction event.