The High Tech Patient in the Low Tech ED

MARA UZCATEGUI, MD
EMERGENCY MEDICINE
TRAUMA/SURGICAL CRITICAL CARE
Introduction

- Increasing prevalence of CHF with more than 5.8 million cases in the United States and more than 23 million worldwide.
- Approximately > 100,000–200,000 have severe, refractory CHF
- The use of left ventricular assist devices (LVADs), is becoming a more popular option as “destination therapy” for end-stage CHF patients
  - limited number of available transplants
  - increasing comorbid conditions
  - technological advances of the implantable devices
Mechanical Ventricular Assist Devices

- Benefits of Ventricular Assist Devices
  - Maintain vital organ perfusion
  - Prevention of SHOCK
  - Reduction of intra-cardiac filling pressures
  - Reduction of congestion and/or pulmonary edema
  - Reduction of LV volumes, wall stress, and myocardial O2 consumption
  - Augmentation of coronary perfusion
  - Supporting the circulation during complex interventional and electrophysiologic procedures
  - Limitation of infarct size
Who benefits from these devices?

- Patients undergoing high-risk PCI
- Large acute myocardial infarctions (AMI)
- Acute decompensated heart failure (ADHF)
- Cardiogenic shock
  - SBP < 90 mm Hg for >30 min
  - Drop in MAP >30 mm Hg below baseline
  - CI <1.8 without hemodynamic support or <2.2 with support
  - Pulmonary capillary wedge pressure (PCWP) >15 mm Hg
Left Ventricular Assist Device (LVAD) Indications

1. Bridge to recovery
   - Temporary Support
     - Post Viral Myocarditis

2. Bridge to transplant
   - Patients awaiting definitive surgical therapy

3. Permanent (destination) therapy
   - Continuously growing
   - Poor Transplant candidates
   - Maximized medical management
Left Atrium to Aorta Assist Device

- TandemHeart
Left Ventricle to Aorta Assist Device

- **Non-Pulsatile Flow**
  - Pump propels blood from the LV into the Aorta
    - Unloads the LV
    - Increases forward flow
    - Reduces myocardial O2 consumption
    - Improves MAP
    - Reduces pulmonary capillary wedge pressure
Impella

- Adequate RV function is necessary
- Contraindications:
  - Mechanical aortic valve
  - Left ventricular thrombus
  - Aortic stenosis and/or regurgitation

9Fr Catheter Diameter

14Fr Compatible with Abiomed’s 14 Fr sheath

14Fr pump motor

Outlet Area

Blood Inlet Area
Impella

- Complications:
  - Limb ischemia
  - Vascular injury
  - Bleeding requiring blood transfusion
  - Hematoma at insertion site
  - Pseudoaneurysm
  - Arterial-venous fistula
  - Retroperitoneal hemorrhage
  - Hemolysis
    - Persistent hemolysis associated with acute kidney injury is an indication for device removal
HeartMate II LVAD

- Used as a permanent therapy in patients with severe heart failure that are not candidates for organ replacement
- FDA Approved since April of 2008
HeartMate II LVAD

- Axial-flow device
  - Continuously draws blood in a nonpulsatile fashion from the inflow orifice (typically in the left ventricle [LV]) to the outflow orifice (typically in the aortic outflow tract)
  - It is this lack of pulsatility that gives patients a benign “pulseless” feeling on physical examination
  - continuous “hum” when auscultating the heart
  - The design of the HeartMate II allows the left ventricle to still function normally
  - Some blood will exit the LV through the aortic valve secondary to the native heart function.

- The level of LV function and the compliance of the aorta will determine the pulsatility of the patient.
Why is this this important for emergency physicians?

- Major adverse events after LVAD implantation
  - Device malfunction
    - Thrombus formation with hemolysis
    - Mechanical failure of the impeller
    - Driveline lead fractures with electric failure
  - Cardiac dysrhythmias
  - Bleeding
  - Thromboembolism
  - Neurological events
  - Infection
Long term considerations and potential complications

- Thromboembolism
  - Implanted device serves as potential nidus for thrombus formation
    - Patients have to be on anticoagulation

- Anemia
  - Chronic mechanical hemolysis from turbulent flow in device

- Platelet Malfunction
  - Acquired Von Willebrand factor (VWF) deficiency from shearing of VWF multimers in device turbine

- GI bleeding
  - Nonpulsatile flow predisposes to development of AV malformations, particularly in the GI mucosa
Long term considerations and complications

- Infection
  - Implanted device, along with driveshaft connecting to battery, a potential site to support bacterial growth

- Dysthrythmias
  - Postsurgical scarring after device implantation alters conduction within myocardium
ED Evaluation of a “High Tech” patient

- Pulses may be difficult to detect because a patient’s HR may not be detectable with nonpulsatile devices.
- Check for a detectable palpable “thrill” in each of the extremities.
- When a thrill is not palpable, Doppler can be used to detect blood flow in the patient.
- Detecting distal blood flow is an indication that the pump is indeed functioning with forward flow to the distal extremities.
Evaluating for Heart Sounds

- It is important to detect the continuous “hum” of the LVAD on auscultation.
- Providers may or may not hear additional heart sounds, depending upon:
  - the residual function of the failing heart
  - the speed of the LVAD motor
- The hum of the device is another indication the device is functioning, in combination with documented pulses.
The Unresponsive Patient

- If unable to detect Doppler pulses in an unresponsive patient
- There has been debate on whether or not to initiate CPR
  - Chest compressions could dislodge the device
- Manufacturers warn of a possible risk of device dislodgement if the chest is compressed
  - Recent evidence-based review showed no evidence of device dislodgement in 10 patients who had CPR
External cardiac compression during cardiopulmonary resuscitation of patients with left ventricular assist devices

Nigel T. Mabvuure** and Jeremy N. Rodrigues

*Glasgow Royal Infirmary, Glasgow, UK  
**Royal Hallamshire Hospital, Sheffield, UK

*Corresponding author. Glasgow Royal Infirmary, Castle Street, Glasgow, UK. Tel: +44-7837537658; e-mail: N.Mabvuure1@uni-bsms.ac.uk (N.T. Mabvuure).

Received 5 February 2014; received in revised form 15 March 2014; accepted 26 March 2014

Abstract

A best evidence topic was written according to a structured protocol to determine whether there is evidence that cardiopulmonary resuscitation (CPR) by compressing the chest is safe and effective in patients with left ventricular assist devices (LVADs). Manufacturers warn of a possible risk of device dislodgement if the chest is compressed. AMED, EMBASE, MEDLINE, BNI and CINAHL were searched from inception to March 2014. Animal studies, case reports, case series, case-control studies, randomized controlled studies and systematic reviews were eligible for inclusion. Opinion articles with no reference to data were excluded. Of 45 unique results, 3 articles merited inclusion. A total of 10 patients with LVADs received chest compression during resuscitation. There was no report of device dislodgement as judged by postarrest flow rate, autopsy and resumption of effective circulation and/or neurological function. The longest duration of chest compression was 150 min. However, there are no comparisons of the efficacy of chest compressions relative to alternative means of external CPR, such as abdominal-only compressions. The absence of high-quality data precludes definitive recommendation of any particular form of CPR, in patients with LVADs. However, data identified suggest that chest compression is not as unsafe as previously thought. The efficacy of chest compressions in this patient population has not yet been investigated. Further research is required to address both the safety and efficacy of chest compressions in this population. Urgent presentation and publication of further evidence will inform future guidance.

Keywords: Left ventricular assist device • External cardiac compression • Chest compression • Cardiopulmonary resuscitation
ED Evaluation of a “High Tech” patient

- Check the BP
  - Automatic blood pressure cuffs do not detect the BP in a patient with an LVAD
  - A manual cuff must be used in these instances, with either auscultation for the first “thrill” heard, or more commonly, use of Doppler to detect distal blood flow as the manual cuff is deflated

- Check the skin for signs of infection
  - The device is implanted in the pre-peritoneum (within a “pocket”), or more commonly within the abdomen

- Inspect of the device site
  - Inspection of the driveshaft, which is the implanted cord that connects the LVAD to the external controller
  - The driveshaft is designed with sufficient slack to minimize accidental “tugging” at the implanted device and to decrease infection risk by increasing the distance from the device to the exit site
ED Evaluation of the “High Tech” Patient

- EKG
  - The exact incidence of dysrhythmias in patients with LVADs is unclear
    - UPMC 2007
      - A study of 111 patients receiving LVAD support as a bridge to transplantation
      - 22% incidence of ventricular dysrhythmias, including VF and VT
    - Denmark 2009
      - 23 consecutive recipients of a HeartMate II
      - Sustained VT or VF occurred in 52% of the patients
      - the majority of arrhythmias occurring in the first 4 weeks after LVAD implantation
      - VT/VF requiring implantable cardioverter-defibrillator (ICD) shock or external defibrillation occurred in 8 patients
      - significant hemodynamic instability ensued in 3 patients
      - There were no clear predictors of VT/VF
      - it is argued that prophylactic ICD implantation should be considered in patients supported with a continuous-flow LVAD.
ED Evaluation of the “High Tech” Patient

- Treat dysrhythmias
  - Amiodarone
  - If unresponsive - Defibrillate
  - If responsive – procedural sedation prior to defibrillation is recommended

- Implantable defibrillator interrogation
Consult Early

- Cardiology / Electrophysiology
- Cardiothoracic surgery
- Perfusionist
- Biomedical engineer
ED Evaluation of the “High Tech” Patient

Patient with LVAD presents with VT, VF, or PVT

Properly assess pulse and BP, using manual cuff and Doppler if available. Listen for mechanical heart sounds and inspect device*

Patient appears unresponsive with undetectable blood flow
  - Initiate CPR

Patient with change in mental status or evidence of poor perfusion, but detectable blood flow
  - Defibrillate/convert immediately

Patient appears stable with detectable blood flow
  - Transport to nearest appropriate facility for conversion of rhythm**
35-year-old woman
No PMHx
Went to local emergency room with 2 days of fevers, chills, and myalgias
Temp: 102°F, BP: 95/60 (72) mm Hg, HR: 110 bpm, RR: 20, O2 sat: 100% on 2 L NC oxygen
Physical examination:
- cool extremities
- clear lungs
- tachycardic heart sounds
She decompensated quickly and developed hypotension, requiring rapid uptitration of norepinephrine to 12 μg kg⁻¹⋅min⁻¹.
ECG showed sinus tachycardia with ST-segment elevation in the inferolateral leads
A cold taken to heart

Lab results
- cardiac troponin of 3.89 ng/mL
- venous lactate of 3.5 mmol/L
- WBC of 17.0
- HB 12.4 g/dL
- Normal hepatic and renal function
A cold taken to heart

- Chest CTA - negative for PE
  - small bilateral pleural effusions
- A bedside transthoracic 2D Echo
  - large pericardial effusion
  - dilated inferior vena cava
  - right atrial and right ventricular (RV) diastolic collapse
  - TLV ejection fraction was visually estimated to be 45% to 50%
- Simultaneous right and left heart catheterization showed elevated filling pressures
- The coronary angiogram was normal
Worsening acidosis (pH 7.2)

Persistent hypotension and tachycardia despite rapidly rising pressors

The patient was taken to the operating room for pericardial window placement to treat tamponade

Despite successful placement of the pericardial window

The patient developed worsening shock

Requiring the emergent placement of an intra-aortic balloon pump while still in the operating

Blood pressure of 83/63 (70) mm Hg, augmenting to 90 mm Hg with an intra-aortic balloon pump at 1:1

HR:130 bpm on milrinone at 0.25 μg/kg/min and norepinephrine at 15 μg/kg/min
U/O had decreased to 15 mL/hr

A Swan-Ganz catheter was placed, which showed elevated filling pressures and a low cardiac output

OR for CentriMag BIVAD implantation

Core heart biopsy was sent to pathology

The intraop TEE revealed small cardiac chambers and an LV ejection fraction of <20%.
Biopsy revealed fulminant lymphocytic myocarditis
Viral serologies were positive for adenovirus and parvovirus
Postop course was quite unremarkable
quick titration off of inotropes and pressors
heparin drip with a PTT goal of 60 to 80 seconds
β-blockers and spironolactone were started on the first postoperative week
After 5 days of maximal biventricular support (6 L/min on the left and 5.5 L/min on the right), support was weaned to 5 L/min on the left and 4.5 L/min on the right
The patient underwent device explantation on day 11.
postexplantation echo showed normal LV and RV size with an EF of 40% to 45%.
Emergent reconnection of severed driveline

- A 67-year-old male
- PMHx of ischemic cardiomyopathy status post HeartWare LVAD implantation as destination therapy 1½ years earlier presented to the ED after acute LVAD failure
- On the morning of presentation, the patient was trying to use the bathroom.
- Sitting on his commode, he attempted to cut the paper tape off of his adult diaper with scissors and accidentally (presumed) and unwitnessed, severed the Heartware LVAD driveline system.
- Upon disconnection from the LVAD, the systems alarms instantly went off and the patient immediately went into cardiac arrest.
- Soon thereafter, his wife started chest compressions, which were continued until emergency medical services (EMS) arrived.
- EMS reported that although he was minimally responsive on their arrival, the patient awoke briefly with initial compressions
Emergent reconnection of severed driveline

- On arrival, he had no appreciable vital signs
- Intubated
- Vascular access was placed
- Inotropic support initiated
- ER doc individually stripped and reconnected the color-coded driveline wires using multiple hemostats, electrical tape, and cardboard
- regeneration of positive LVAD flows
- Transfer!
Emergent reconnection of severed driveline
Emergent reconnection of severed driveline

- On arrival, VT at 175 beats/min and a MAP of 40 mm Hg with LVAD flows of 4 L/min.
- Cardioverted (200 J), which successfully returned him to sinus rhythm.
- The patient was placed on dobutamine, epinephrine, norepinephrine, and vasopressin infusions.
- Urgent TEE was performed, which showed flow through the aortic cannula, right ventricular function was mild to moderately depressed, and no pericardial effusion was noted.
- Swan Ganz catheter placement for further invasive hemodynamic monitoring.

- Physical examination
  - sluggishly reactive pupils
  - + gag reflex
  - no withdrawal to pain
  - cool distal extremities
  - On neurological evaluation after 24 h off sedation, the patient maintained brainstem reflexes.
  - he did not withdraw to pain
  - no spontaneous movements
  - Care was withdrawn on day 7 due to the patients’ poor neurological prognosis.
Questions?

- Thank you!
- marauzcategui@gmail.com