Long term heart failure management and treatment

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Objectives
- Define end-stage heart failure
- Define cardiogenic shock
- Verbalize treatment goals for end-stage heart failure patients
- Discuss temporary mechanical circulatory support (MCS) devices for heart failure patients
- Review durable mechanical circulatory support devices (MCS)

Advanced Heart Failure
- The presence of progressive and/or persistent severe signs and symptoms of heart failure despite optimized medical, surgical, and device therapy. It is generally accompanied by frequent hospitalizations, severely limited exertional tolerance and poor quality of life and is associated with high mortality. Importantly, the progressive decline should be primarily driven by the heart failure syndrome.
Cardiogenic Shock

Definition:
An acute physiological condition caused by the inability of the heart to pump sufficient blood for the needs of the body

- Signs of peripheral hypoperfusion:
  - Cold extremities, AMS, elevated lactate, oliguria
- Hemodynamic abnormalities:
  - SBP < 90mmHg for > 30 minutes
  - Cardiac Index < 2.2L/min/m²
  - Evidence of elevated filling pressures (right, left, or both)
    - Wedge > 15mmHg
    - RA > 10mmHg
- Refractory to medical therapy

Stages of Cardiogenic Shock

Heart failure treatment goals

- Improve symptoms and quality of life
- Slowing the progression or reversing cardiac and peripheral dysfunction
- Reducing mortality

ACC/AHA/NHLBI 2013 treatment guidelines
Case Study

- 51 year old male suffered cardiac arrest at home. Upon EMS arrival EKG shows STEMI. Coronary angiogram showed 3 vessel CAD with 90% left main lesion. IABP was placed and PCI attempted but patient had PEA arrest. He was taken emergently to the OR for revascularization. He suffered arrest in OR with PEA and VT and received 30 minutes of CPR. He was placed on VA ECMO and transferred to Nebraska Medicine for advanced heart failure evaluation.

Case Study

- Upon arrival to Nebraska Medicine
- VA ECMO with 4L.min flow at 3200 rpm through left groin
- IABP set at 1:2
- Norepinephrine at 1.7 mcg/kg/min
- Epinephrine at 0.55 mcg/kg/min
- Lidocaine at 1 mg/min
- Amiodarone at 1 mg/min

Case Study

- Lactic acid
- ABG
  - pH: 7.09
  - pCO2: 47
  - PO2: 381
  - SVO2: 57.7
- Echo
  - Severely depressed LV function, ef 5-10%, severely depressed RV function
- Labs on admission
  - WBC: 26.7
  - Hemoglobin: 11
  - Hematocrit: 34
  - Platelets: 289
  - Na: 137
  - K: 3.2
  - BUN: 32
  - Creatinine: 2.33
  - AST: 568
  - ALT: 286
Case Study

• Placement of right femoral impella
• Removal of right IABP
• Left lower extremity angiogram

Nephrology consulted and started on CVVHD

Treatment options??

Types of Mechanical Circulatory Support

• Intra-aortic balloon pump (IABP)
• Impella
• TandemHeart
• Protek Duo Cannula
• CentriMag ventricular assist device
• Extracorporeal membrane oxygenation (ECMO)
• Durable LVAD
IABP

- First studies published in 1960s
- Initially studied as external counterpulsation
- Other groups removed blood during systole, replaced it during diastole
- Moulopoulos first group to use latex tubing tied around a catheter
- Adrian Kantrowitz first clinical use, published in JAMA 1968
- Gained more widespread clinical use in 1970s

IABP Effects

- Afterload is decreased via a vacuum effect by rapid balloon deflation (20% decrease in SBP)
- Increases aortic diastolic BP by 30% (helps increase coronary blood flow)
- Decreases myocardial oxygen consumption (by decreasing isometric phase of LV contraction)
- Decreases LV wall tension (by decreasing peak rate of LV pressure rise)
- Increase in LVEF
- Increase in cardiac output by 0.5-1L/min
- LVEDP decreases
IABP

• Contraindications
  • Moderate to Severe AR
  • Aortic dissection
  • AAA

• Complications
  • Thrombocytopenia, Thrombosis
  • Obstruction of arterial flow in malposition
  • Aortic rupture/dissection
  • Air or plaque embolism
  • Access site complication

Impella

• Technology first approved in Europe in 2005
• 2.5 FDA approved in 2008, CP approved in 2012
• Microaxial flow pump built onto a 9F catheter
• Sits across the aortic valve
• Aspirates blood from the LV and expels the blood into the proximal ascending aorta
• Comes in three different sizes as well as a RV support device
Impella

• Unloads LV
  • Decreases LVEDP
  • Decreases LV wall tension
  • Decreases LV myocardial oxygen demand
• Increases MAP
  • Improved systemic and coronary perfusion
• Decreases wedge pressure
  • Can also lead to in RV afterload
• Can be inserted in combo with VA-ECCMO
• Acts as an LV vent
• Helps reduced LVEDP and wall tension
Impella

• Contraindications
  • LV thrombus
  • Moderate-Severe AS
  • Moderate-Severe AR
  • Recent TIA/CVA
  • Aortic abnormalities
  • Contraindication to anticoagulation

• Complications
  • Vascular site injury
  • Hemolysis
  • Device migration
  • Aortic valve injury
  • Aortic insufficiency
  • Ventricular arrhythmia

TandemHeart

• CardiacAssist Inc, Pittsburgh, PA
• Femoral access
• Transseptal puncture with cannula in the left atrium (21F)
• Blood returned to femoral artery (15 or 17F)
• Centrifugal pump located outside the body
• Can provide 3.5-4 L/min flow
• Gained FDA approval in 2003

www.tandemlife.com

TandemHeart

• Preload dependent (ideal wedge 18-20mmHg)
• Systemic anticoagulation is needed
• Swan is recommended to monitor hemodynamics
• Unloads the LV better than VA-ECMO

• Complications
  • Limb ischemia (3%)
  • Bleeding (29%)/Need for blood transfusions (71%)
  • Embolism (CVA 6.8%)
  • Risk of tamponade following transseptal puncture
  • Sepsis/SIRS (29.9%)
Protek Duo Cannula

- Cannula utilized to provide RV support
- Single access site
- Inserted via right IJ
- Drains blood from the RA with return tip in main PA
- Provides up to 4L/min flow for RV support
- Can be pulled at bedside
- Can be used with TandemHeart or CentriMag +/- Oxygenator

VA-ECMO

- Idea of extracorporeal circulation started in 1931
- Dr. John Gibbon in 1931 in Philly
- Cared for a young woman who died from PE
- He wrote “the idea naturally occurred to me that that extracorporeal circulation should be possible”
- Eventually faculty position at Jefferson and studied pump devices for next 20 years
- In 1951, first heart-lung machine used at U of Minnesota, patient died
- In 1953, Gibbon used a heart-lung machine to operate on young girl with ASD
- This was the beginning of modern cardiac surgery and ECMO development

VA-ECMO Utilization

- The number of ECMO admissions and hospitals performing ECMO have increased exponentially
- ECMO encounters have increased 361% from 2008 to 2014
  - From 1,106 pts in 2008 to 4,875 pts in 2014
  - From 206 hospitals 2008-2011 to 660 in 2012-2014
- Over 87,000 patients have been enrolled in ELSO registry
- Mo
VA-ECMO

- Deoxygenated blood pulled from venous circulation
- Blood pumps through oxygenator
- Oxygenated blood returns to arterial circulation

- Venous cannula at least 21 F and typically within intra-hepatic IVC
- Arterial cannula typically 15-19 F
- Frequently distal perfusion catheter is placed downstream of arterial cannula (6-10 F)

VA-ECMO Equipment

- Oxygenator
  - Semi-permeable membrane
  - Higher the gas flow, more CO2 that is removed
- Sensor
  - Measures flow
- Pump
  - Centrifugal
- Hand crank
  - Used when there is pump failure
VA-ECMO Hemodynamics

- Venous drainage leads to reduced flow through lungs (RV unloading)
- Increase in systemic afterload
- Increase in LV pre-load/LVEDP
- Consequently, LA and wedge pressures increase
  - Can lead to pulmonary edema
  - Inotropic support can be used to help facilitate LV unloading
  - LV venting strategy (IABP, Impella, surgical cannula) may be needed
- Increase myocardial oxygen demand
- Gas exchange unit allos normalization of blood gases (unlike other forms of MCS)
- “Harlequin Syndrome”
  - Deoxygenated blood ejected from LV
  - Well-oxygenated lower body

VA-ECMO Complications

- Vascular complications – dissection, pseudoaneurysm, RP bleeding
- Limb ischemia – 13-25% (some reports up to 70%)
- Thrombosis – 1-22%
- Bleed, coagulopathy, hemolysis – 5-79%
- Infection – 17-49%
- Neurologic Events – 10-33%

Case Study

- Treatment Options
- Continue support with ECMO and Impella
- Durable LVAD
- List for transplant
- Palliative care
Case Study

- Evaluated for Advanced Heart Failure Therapies
- Approved for LVAD as DT (due to smoking) with planned RVAD support
- Underwent implant of HM3 LVAD with CentriMag RVAD and VV ECMO
- Decannulation of VA ECMO

LVAD

- The pump is preload dependent. Therefore two factors that affect pump function are:
  - Volume status
  - Right ventricular function
- The pump is also affected by afterload. Increased blood pressure makes the pump work harder and decreases its effectiveness.
  - At any given speed, increased blood pressure decreases flow through the pump.
Three Different LVADs

HeartMate II  HeartWare  HeartMate 3

LVAD

LVAD Flow Principles

• Pump flow is a function of:
  • The speed of the rotor
    ↑Speed ⇒ ↑Flow  
    ↓Speed ⇒ ↓Flow
  • The difference in pressure across the pump
    ↑Pressure gradient ⇒ ↑Flow  
    ↓Pressure gradient ⇒ ↓Flow

At any given speed, increased B/P will decrease flow
CentriMag

- CentriMag uses free-floating magnetically levitated rotor to provide support as part of cardiopulmonary circuit or extracorporeal bypass circuit

- RVAD
  - Right atrium as inflow the main pulmonary artery as the outflow

- LVAD
  - The outflow is the ascending aorta and inflow is chosen based on patient condition


Case Study

- Failed RVAD turn down study
- Discussed again at PSC
- Listed as a status 1 for heart transplant
- Underwent heart transplant 2 days after listing