2016 ANNUAL MEETING

MAN VERSUS MACHINE: A PHARMACIST’S ROLE WITH VASCULAR DEVICES

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DISCLOSURES

• Otsanya Ochogbu, PharmD
  I do not have a vested interest in or affiliation with any corporate organization offering financial support or grant monies for this continuing education activity, or any affiliation with an organization whose philosophy could potentially bias my presentation

• Davide Ventura, PharmD
  I do not have a vested interest in or affiliation with any corporate organization offering financial support or grant monies for this continuing education activity, or any affiliation with an organization whose philosophy could potentially bias my presentation

ABBREVIATIONS

• MCS – mechanical circulatory support
• IABP – intra-aortic balloon pump
• LV – left ventricle
• RV – right ventricle
• SBP – systolic blood pressure
• MAP – mean arterial pressure
• CO – cardiac output
• CI – cardiac index
• PCWP – pulmonary capillary wedge pressure
• ECMO – extracorporeal membrane oxygenator
• CF-LVAD – continuous flow left ventricular assist device
• PP-LVAD – pulsatile flow left ventricular assist device
• LVAD – left ventricular assist device
• HVI – HeartWare
• HVIAD – HeartWare ventricular assist device
• VAD – ventricular assist device
• HHEF – heart failure with reduced ejection fraction

OBJECTIVES

• Identify patient selection criteria for circulatory support devices
• Differentiate between the percutaneous, extracorporeal, and implantable circulatory support devices
• Compare immediate post-operative and long-term outpatient care in the management of circulatory support devices
• Summarize associated antithrombotic therapy
• Outline complications associated with circulatory support devices
• Explore areas for potential errors and ways to prevent them

EVOLUTIONARY TREE

• Percutaneous Circulatory Devices
• Implantable Circulatory Devices
• Anticoagulation
• Complications

CARDIOGENIC SHOCK

• Cardiogenic shock: state of end-organ hypoperfusion caused by LV, RV or biventricular injury resulting in pump failure
• Defined as:
  • Persistent hypotension [SBP < 90mmHg, or decrease in MAP by 30mmHg from baseline]
  • CI < 1.8L/min/m² without support or < 2.0 to 2.2L/min/m² with support
  • Elevated filling pressure
  • Clinical signs and symptoms of hypoperfusion
  • Myocardial infarction with LV failure remains leading cause of cardiogenic shock

CARDIOGENIC SHOCK

WHERE DOES MCS FIT INTO MANAGEMENT?

- Cardiogenic shock secondary to ST-elevation myocardial infarction
  - LV assist devices for circulatory support may be considered in patients with refractory cardiogenic shock (Level of evidence: C)
- Stage D HFREF
  - Short-term MCS is reasonable as a "bridge to recovery" or "bridge to decision" for selected patients with acute profound disease (Level of evidence: B, Iia)
  - Long-term MCS is reasonable to prolong survival for carefully selected patients with stage D HFREF (Level of evidence: B, Iia)

PERCUTANEOUS MECHANICAL CIRCULATORY DEVICES

PERCUTANEOUS CIRCULATORY SUPPORT SYSTEMS

- In acute presentations percutaneous devices offer an advantage by avoiding invasiveness of surgical implantation
- What makes for an ideal percutaneous circulatory support system?
  - An approach that allows for quick and easy deployment
  - Provide hemodynamic support and myocardial protection
  - Low complication rate i.e. favorable risk:benefit ratio

CARDIOGENIC SHOCK KILLS!

PERCUTANEOUS CIRCULATORY SUPPORT SYSTEMS

A AIBP  B Impella  C TandemHeart
INTRA-AORTIC BALLOON PUMP
• Originally developed in 1968
• Most frequently used cardiac assist device
• Inserted through the femoral artery or subclavian artery (surgical approach)
• Positioned in the descending thoracic aorta

HEMODYNAMIC EFFECTS OF MCS

<table>
<thead>
<tr>
<th>IABP</th>
<th>Impella</th>
</tr>
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<tbody>
<tr>
<td>Preload</td>
<td>↓</td>
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<tr>
<td>PCWP</td>
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<tr>
<td>Afterload</td>
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<tr>
<td>Cardiac output</td>
<td>(0.5 – 1L/min)</td>
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</table>

THE IMPELLA FAMILY
• Currently available products:
  • Impella 2.5
  • Impella CP
  • Impella 5.0
  • Impella RP
  • Impella LD
• Micro-axial rotary pump placed across the aortic valve
• Aspirates oxygenated blood from the left ventricle into the ascending aorta
• Require anticoagulation purge solution – contains heparin in D5W or D20W
• Goal ACT 160 - 180

DOES IABP IMPROVE SURVIVAL?

HEMODYNAMIC EFFECTS OF MCS

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<td>Cardiac output</td>
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</table>
THE IMPELLA FAMILY

- No randomized controlled trials have evaluated mortality as a primary endpoint in patients with cardiogenic shock with implantation of an Impella
- Several studies have demonstrated improvement in hemodynamic parameters
  - Higher CI
  - Increase in MAP
  - Decrease in PCWP
  - Lactate clearance
- Did not translate to mortality benefit when compared to IABP
  - 30 day mortality: 46% (Impella) vs. 46% (IABP)

TANDEM HEART

- Continuous flow centrifugal pump
- Inserted under fluoroscopy through the femoral vein
- Trans-septal puncture through RA into the LA
- Oxygenated blood is aspirated from the LA and returned to arterial circulation via femoral artery
- Approved for short-term support
- Systemic anticoagulation with heparin
  - Goal aPTT 50 - 70

HEMODYNAMIC EFFECTS OF MCS

<table>
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<th>TandemHeart</th>
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<td>(2.5 – 5L/min)</td>
<td>(4L/min)</td>
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HOW DOES TANDEMHEART COMPARE TO IABP?

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EXTRACORPOREAL MEMBRANE OXYGENATOR (ECMO)

- Supports heart and lung
- Blood drained from venous circulation and returned to arterial circulation
- Central or peripheral cannulation
- Reported survival ~53%

FORMS OF ECMO

VENOUS-ARTERIAL ECMO (VA ECMO)
- Supports heart and lung
- Blood drained from venous circulation and returned to arterial circulation
  - Central or peripheral cannulation
  - Reported survival ~53%

VENOUS-VENOUS ECMO (VV ECMO)
- Supports lung
- Blood drained from venous circulation and returned to venous circulation
- Peripheral cannulation
### Hemodynamic Effects of MCS

<table>
<thead>
<tr>
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### ECMO and Drug Clearance
- Decreased drug clearance
- Occurs by many mechanisms
  - Renal dysfunction: approximately 50% of patients on VV ECMO and 41% of patients on VA ECMO require RRT
  - Hypoxia/hypoperfusion injury
  - Alterations in regional blood flow

### Pharmacokinetic Changes with ECMO

- Decreased drug clearance
-Occurs by many mechanisms
- Renal dysfunction: approximately 50% of patients on VV ECMO and 41% of patients on VA ECMO require RRT
- Hypoxia/hypoperfusion injury
- Alterations in regional blood flow

### Complications of ECMO
- Bleeding – most common
- Infection
- Lower extremity ischemia – more common with femoral cannulation site
- Air emboli
- Thrombus formation

### ECMO and Drug Sequestration
- In-vitro studies have demonstrated significant drug sequestration within ECMO circuit
- Increase in volume of distribution
- Sequestered drug can serve as a reservoir ➔ prolonged pharmacologic effect
- Factors that affect drug sequestration
  - Molecular size
  - Lipophilicity
  - Degree of ionization
  - Plasma protein binding

### When the Iron Lung Rusted: Anticoagulation in ECMO
HEMOSTASIS

THROMBOTIC MANIFESTATIONS

PATHOPHYSIOLOGY OF CLOT FORMATION

ANTICOAGULATION MONITORING: ALPHABET SOUP

THROMBOTIC COMPLICATIONS

ACT VS. APTT
ATALLAH ET AL.
- Retrospective analysis from 2011 – 2012 evaluating 46 patients on ECMO
- Primary endpoints:
  - Correlation between heparin dose and either aPTT or ACT
  - Paired ACT and aPTT
- Secondary endpoints
  - Assessment of factors affecting coagulation monitoring

Evaluation of the activated clotting time and activated partial thromboplastin time for the monitoring of heparin in adult extracorporeal membrane oxygenation patients

**Additional Findings:**
- Higher correlation between aPTT in patients undergoing VA ECMO, no CRRT, and an INR <1.5
- aPTT paired with ACT showed poor correlation

**ANTITHROMBIN III**
- Atryn
- Thrombate

**IMPLANTED VENTRICULAR ASSIST DEVICES**
- 2016 ANNUAL MEETING
**WHO GETS A VAD?**

<table>
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<tr>
<th>NYHA</th>
<th>Stage C</th>
<th>Stage D</th>
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<tr>
<td>Class III</td>
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**INTERMACS**

<table>
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<tr>
<th>INTERMACS Patient Descriptions</th>
<th>Time to MCS</th>
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<tr>
<td>1 Cardiogenic Shock</td>
<td>Crash and Burn</td>
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<tr>
<td>2 Progressive Decline</td>
<td>&quot;Sinking Ship&quot;</td>
</tr>
<tr>
<td>3 Stable but Inotropic Dependent</td>
<td>&quot;Sliding Fast&quot;</td>
</tr>
<tr>
<td>4 Recurrent advanced HF</td>
<td>&quot;Frequent Flyer&quot;</td>
</tr>
<tr>
<td>5 Exertion Limited</td>
<td>&quot;Walking Wounded&quot;</td>
</tr>
<tr>
<td>6 Exertion Limited</td>
<td>&quot;Walking Wounded&quot;</td>
</tr>
<tr>
<td>7 Advanced NYHA Class III</td>
<td>Not a candidate</td>
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**IN THE BEGINNING....**

- HeartMate I (XVE) - Pneumatically driven
- HeartMate II
- Heartware - HVAD
- HeartMate XVE
- Thoratec PVAD
- Novacor

**THE EVOLUTION OF MAN AND MACHINE**

- 3rd Generation
  - HeartMate III
  - Heartware - HVAD
- 2nd Generation
  - HeartMate II
  - Jarvik 2000
- 1st Generation
  - HeartMate XVE
  - Thoratec PVAD
  - Novacor

**PATIENT SELECTION**

**HEARTMATE XVE**

**REMATCH TRIAL**
REMATCH
- Multi-center, randomized, non-blinded study
- Assessed outcomes between LVAD vs. Optimal Medical Therapy (OMT)
- **Primary endpoint**
  - Death from any cause
- **Secondary endpoints**
  - Serious adverse events
  - Days of hospitalization
  - Quality of life
  - Symptoms of depression
  - Functional Status

SURVIVAL WITH HEARTMATE XVE
- One year survival
  - LVAD: 52%
  - OMT: 23%
- 2-year survival
  - LVAD: 23%
  - OMT: 8%

HEARTWARE DESIGN - CENTRIFUGAL FLOW

NOT A COMPLETE VICTORY
- Disadvantages of the HeartMate XVE
  - Infection
  - Frequent bleeding events
  - Neurological deficits
  - Audible pump
  - Extensive surgical dissection
  - Large external lead
  - Durability
  - Body habitus

A CONTINUOUS EVOLUTION - 2ND GENERATION VADS
- HeartMate II, Jarvik 2000
  - Continuous flow devices
  - Axial rotator design
  - Smaller drivelines and rotor design
  - Silent mechanics
  - More durable
THE FUTURE GENERATIONS

HeartMate III
- Mixture of continuous AND pulsatile flow via centrifugal impeller
- Full magnetic technology

HeartAssist 5
- Modified axial flow pump with pulsatile flow

CONTINUOUS FLOW VS. PULSATILE FLOW

- GI bleeding
- Aortic insufficiency
- RV failure
- LV remodeling and recovery
- End-organ perfusion

IN SUMMARY

YOU GOT A VAD, WHAT NEXT?
- Hemodynamic optimization:
  - Maintenance of sinus rhythm
  - MAP between 60 – 80mmHg
  - CVP and PCWP less than 15mmHg
  - CI greater than 2.5L/min/m²
- Optimize VAD settings prior to the use of vasoconstrictors, vasodilators or inotropes
- Heart rate and rhythm managed with epicardial pacing

HEMODYNAMIC OPTIMIZATION

<table>
<thead>
<tr>
<th>CI</th>
<th>MAP</th>
<th>LV ejection</th>
<th>Primary recommendation</th>
<th>Alternative</th>
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<td>&lt; 2.2</td>
<td>&lt; 65</td>
<td>No</td>
<td>Ephedrine, Norepinephrine</td>
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<td>&lt; 2.2</td>
<td>&gt; 65</td>
<td>No</td>
<td>Dobutamine, Milrinone</td>
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<td>&lt; 60</td>
<td>Yes</td>
<td>Increase pump speed</td>
<td>Volume for low CVP</td>
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<tr>
<td>&gt; 2.2</td>
<td>&gt; 60</td>
<td>Yes</td>
<td>Increase pump speed</td>
<td>Sodium nitroprusside</td>
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<td>Milrinone, Sodium nitroprusside</td>
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<td>&gt; 90</td>
<td>Yes</td>
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### Hemodynamic Optimization

<table>
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<tr>
<th>CI</th>
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<tr>
<td>&gt; 2.2</td>
<td>&gt; 65</td>
<td>No</td>
<td>Norepinephrine</td>
<td>Vasopressin</td>
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<tr>
<td>&gt; 2.2</td>
<td>&gt; 65 and &lt; 90</td>
<td>Yes</td>
<td>Norepinephrine</td>
<td>Vasopressin</td>
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<td>&gt; 65 and &lt; 90</td>
<td>No</td>
<td>No intervention</td>
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<td>&gt; 2.2</td>
<td>&gt; 90</td>
<td>No</td>
<td>Sodium nitroprusside</td>
<td>Nilotherapy</td>
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<td>&gt; 2.2</td>
<td>&gt; 90</td>
<td>Yes</td>
<td>Sodium nitroprusside</td>
<td>Nicardipine</td>
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### Post-Operative Care

- Arrhythmias should be treated with external cardioversion and antiarrhythmics
- Enteral nutrition should be initiated as soon as feasible possible
- Initiate anticoagulation once hemostasis is achieved
- Early mobility and physical therapy

### HeartMate II Anticoagulation

- As of March 2011 thrombotic events increased from 2.2% to 8.4% in the first 3 months
- Median time to thrombosis:
  - Pre March 2011: 18.6 months
  - Post March 2011: 2.7 months
- 48% Mortality at 6 months in patient without pump exchange or transplant

### Boyle et al.

- 331 patients assessed
- Thrombotic Events: 10
- Hemorrhagic Events: 58

### Starling et al.

- Unexpected Abrupt Increase in Left Ventricular Assist Device Thrombosis

- Dr. Randall C. Starling, M.D., M.P.H., Nader Mozamz, M.D., Scott C. Silvestry, M.D., Gregory Ewald, M.D., Joseph G. Rogers, M.D., Carmelo A. Milano, M.D., J. Eduardo Ramon, M.D., Michael A. Ackers, M.D., Eugene H. Blackstone, M.D., John Ehrlich, Ph.D., Lucy Thulla, M.S., Maria M. Mumentis, D.O., Edward G. Sorto, M.D., M.P.H., Bruce W. Lytke, M.D., and Nicholas G. Smedira, M.D.
PREVENTION OF HEARTMATE II PUMP THROMBOSIS THROUGH CLINICAL MANAGEMENT (PREVENT) TRIAL
• Non-randomized, multicenter
• n = 300
• Demographics
  • 83% Male
  • Mean age: 57 y/o
  • Bridge-to-transplant: 78%
• Anticoagulation
  • Heparin within 48 hours post implantation
  • Warfarin within 48 hours: INR 2-2.5
• Antiplatelet Therapy
  • Aspirin within 2 to 5 days: 81-325 mg daily

VAD ANTIICOAGULATION

<table>
<thead>
<tr>
<th>Device</th>
<th>IV Heparin Bridging</th>
<th>Warfarin</th>
<th>Anti-Platelet Agent</th>
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</thead>
<tbody>
<tr>
<td>HeartMate II</td>
<td>POD 1 to 2: alpTT 40-60</td>
<td>Start on POD 3 to 5: INR 2.5</td>
<td>Aspirin 81 - 325mg daily + Dipyridamole 75 mg 3x/day</td>
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<tr>
<td>HeartWare</td>
<td>POD 3 to 4: alpTT 60-80</td>
<td>Start POD 4: INR 1.5 - 2.5</td>
<td>Aspirin 81-325 mg daily + Dipyridamole/Aspirin 200mg/25mg daily or Clopidogrel 300mg load with 75mg maintenance dose</td>
</tr>
</tbody>
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THE FIRST 30 – 60 DAYS
• Cumulative incidence of adverse events estimated at 89%
• Arrhythmias, bleeding, and infection most common early complications
• Arrhythmias occur in 30-60% of patients
  • Most commonly: atrial fibrillation, ventricular tachycardia and ventricular fibrillation
  • Lead to RV dysfunction
  • Increase risk of intra-cardiac thrombus
• Treatment
  • Treat underlying cause
  • Correct electrolytes
  • Antiarrhythmics – amiodarone, β-blockers
  • Electrical cardioversion

VAD COMPLICATIONS

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The First 30 – 60 Days
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Bleeding
• Significant bleeding post-VAD implantation occurs in 31-81% of patients
• Incidence of fatal bleeding ~3%
• Typically presents as:
  • Excessive surgical drainage
  • Hemorrhagic shock
  • Tamponade ~ 28%
  • Excessive post-op bleeding increases risk of infection and RV failure

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Sidebotham et al. Best Practice and Research Anesthesiology. 2012;26:231-246

Bleeding
• Perioperative factors that increase risk of bleeding
  • Pre-operative anticoagulation
  • Poor nutritional status
  • Hepatic congestion
  • Large volume transfusion
  • Post-operative anticoagulation
  • Activation of inflammatory and coagulation cascade by cardiopulmonary bypass circuit
• Prevent bleeding by modifying factors prior to VAD implantation
LATE COMPLICATIONS: >60 DAYS

Device related
- Device failure
- Cannula obstruction
- Aortic valve degeneration

Non-device related
- Thromboembolism
- Hemorrhagic complications
- RV dysfunction
- Infections
- Arrhythmias

PUMP THROMBOSIS

PUMP THROMBOSIS RATES

HeartMate II
- Thrombosis rates 3.3% higher than pre-2010 era
- Risk factors:
  - Younger age
  - Higher BMI
  - Severe right heart failure
  - Later date of implantation

HMIVAD
- Thrombosis rates 0.68 Events Per Patient Year vs. 0.68 in pre-2010 era
- Risk Factors
  - MAP > 90 mmHg
  - Aspirin doses < 81 mg
  - INR < 2
  - INTERMACS profile of >3

WHY THE SURGE?

Anticoagulation protocols from Cleveland Clinic, Barnes Jewish Hospital, and Duke University Medical Center by era

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<td>Routine Heparin Bridging</td>
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<td>Target INR</td>
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<td>1.5 to 2.5</td>
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<tr>
<td>Antiplatelet Agents</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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WHY DO VADS CLOT

Pump Related
- Heat from impeller
- Surface interactions
- Shear stress
- Areas of stasis
- Cannulation site thrombus
- Outflow graft impingement
- Inflow cannula malposition

Patient Related
- Atrial Fibrillation
- Valve prostheses
- Sepsis
- Non-compliance
- Low flow disease states
- Hypercoagulable state

Management Related
- Low INR
- Absence of antiplatelet medications
- Low flow due to RPM settings

PUMP THROMBOSIS

DIAGNOSIS OF PUMP THROMBOSIS

Clinical Findings
- Abnormal pump sounds
- Hypotension
- Dizziness
- Worsening renal function
- Volume overload

Pertinent Laboratory Values
- Lactate Dehydrogenase > 3x ULN
- Plasma free-hemoglobin > 40 mg/dL
- Elevated LFTs
- Low haptoglobin
- Elevated fibrin split products
**DIAGNOSIS OF PUMP THROMBOSIS**

**Outflow graft**

**Impeller**

**Inflow graft**

**MANAGEMENT OF PUMP THROMBOSIS**

**Power Elevations**

- Early vs. Late?
- LV unloading?

**Isolated LDH Rise**

- Hemolysis?
- LV unloading?
- Optimize antithrombotics

**Hemolytic New CHF Symptoms**

- Admit to hospital
- Consider heparin
- Trend hemolysis surrogate labs
- LV unloading?
- Inflow/Outflow concerns?
- Inotropes/Diuretics?
- Direct Thrombin Inhibitors?
- Thrombolytics?

**Medical Management**

- Heparin
- Briskures/Argatroban
- Eptifibatide
- Alteplase

**50% Mortality**

**5% Mortality**

**Surgical Management**

- Octreotide
- DDAVP
- Estrogens
- Surgical exploration
- Upgrade transplant waitlist

**GASTROINTESTINAL BLEEDING**

**Initial Management**

- Stop antithrombotic
- Blood transfusions (risk of alloimmunization)
- PPI and vitamin K

**Evaluation Strategy**

- Invasive
- Conservative

**Treatment**

- Upper/Lower Endoscopy
- Octreotide
- DDAVP
- Surgical exploration
- Upgrade transplant waitlist
- Observe for bleeding

**WHEN THE RIGHT SIDE FAILS**

- RV failure is a clinical syndrome that impairs the ability of the RV to fill and eject appropriately
- Reported incidence 20 – 50%

**GASTROINTESTINAL BLEEDING**

- Most common late complication following VAD implantation
- Higher incidence with continuous versus pulsatile flow VADs
  - 63 events/100 patients-yrs (CF-LVAD) vs. 6.8 events/100 patients-yrs (PF-LVAD); p<0.0004
- Primary location is upper GI tract, mostly from arteriovenous malformations
- Etiology
  - Acquired von-Willebrand factor (vWF) deficiency
  - Platelet activation
  - Acquired von-Willebrand factor (vWF) deficiency
  - Platelet activation

**WHEN THE RIGHT SIDE FAILS**

- Pre-operative prevention: optimize preload, afterload and contractility prior to LVAD implantation
- Pharmacologic management
  - Inotropes with pulmonary vasodilation – dobutamine, milrinone
  - Pulmonary vasodilators – iNO, epoprostenol, sildenafil
  - Avoid α-adrenergic stimulation – phenylephrine
  - Implantation of RVAD – last resort
INFECTIONS

- Infections are common in patients with VADs
- Lower incidence with CF-VADs versus pulsatile VADs
- Associated with increase hospital LOS, reoperation and organ failure
- Strategies to reduce risk of infection
  - Optimize nutritional status
  - Minimize indwelling catheters
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STRATEGIES TO REDUCE RISK OF INFECTION

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DRIVELINE INFECTIONS

- Commonly superficial but can extend into muscle or fascial layers
- Present with purulent secretions, cellulitis, wound dehiscence
- Management
  - Culture + gram stain of drainage
  - Antibiotic selection based on site antibiogram and culture data
  - Vacuum-assisted closure of wounds where applicable
  - Superficial infections – short course of antibiotics is appropriate
  - High rates of recurrence

DEVICE RELATED INFECTIONS

- Pocket infections
  - Extension from driveline or inoculation during surgery
  - Diagnosed with ultrasound or CT
  - Fluid aspiration for culture/gram stain
  - I&D, surgical revision
  - Chronic oral suppressive therapy
- Cannula/pump infections
  - Infection of internal portions of pump or cannula
  - Develops with persistent bacteremia
  - TTE or TEE to identify vegetations
  - Antibiotics – IV and oral
  - VAD exchange required

NEUROLOGIC COMPLICATIONS

- Reported incidence is 2 – 48% following VAD implantation
- Strokes can be ischemic or hemorrhagic
- Risk factors
  - Level of anticoagulation
  - Hypotension
  - Hyperpotension
- Management similar to non-VAD patients
INCIDENCE OF NEUROLOGIC OUTCOMES

<table>
<thead>
<tr>
<th></th>
<th>Hemorrhagic CVA (Events per PT-year)</th>
<th>Non-hemorrhagic CVA (Events per PT-year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HM2/VRB BTN</td>
<td>0.05</td>
<td>0.13</td>
</tr>
<tr>
<td>HM2 Extended (n=281)</td>
<td>0.05</td>
<td>0.09</td>
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<tr>
<td>HM2 DT (n=133)</td>
<td>0.07</td>
<td>0.06</td>
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<tr>
<td>HM2 Post-FDA (n=159)</td>
<td>0.01</td>
<td>0.06</td>
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<tr>
<td>HM2 European (n=971)</td>
<td>0.04-0.05</td>
<td>0.04-0.09</td>
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<tr>
<td>HVAD European (n=100)</td>
<td>0.08</td>
<td>0.05</td>
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<tr>
<td>HVAD Advance</td>
<td>0.06</td>
<td>0.10</td>
</tr>
</tbody>
</table>


THE END OF OUR ODYSSEY

- Short term percutaneous MCS offer support as a bridge to recovery or long-term solution
- Numerous complications are associated with ventricular assist devices
- Anticoagulation is a fundamental part of all circulatory devices
  - All Impella devices must have a heparin based purge solution with D5W only
  - ECMO anticoagulation is contingent on adequate anti-thrombin III levels usually between 80 – 120%
  - VADs require long term warfarin therapy with an INR of 2-3 but is very patient specific in an effort to balance pump thrombosis vs. GI bleeding

QUESTIONS????