Percutaneous Mechanical Circulatory Support Devices

Key Article

- *Miller PE, et al. Advanced percutaneous mechanical circulatory support devices for cardiogenic shock. Crit Care Med. 2017; 45:1922-1929.*

Background

- Cardiogenic shock complicates approximately 8% of STEMIs
- Mortality is extremely high and approaches 50%
- Traditional treatment of cardiogenic shock has been vasoactive agents (pressors and inotropes) and possibly IABP while attempting to get patient to PCI or CABG
- IABP relatively recently shown to have no mortality benefit in IABP-SHOCK II trial –
- Recommendation for use of IABP has been downgraded from class I to IIa in both the US and Europe
- Similarly, percutaneous mechanical circulatory support also given a class IIb recommendation
- Notwithstanding, use of these percutaneous ventricular assist devices has increased more than 30-fold over past several years

Goal of Percutaneous Mechanical Circulatory Support Devices

- Improve cardiac function while awaiting reversal of the cause of cardiogenic shock

Current Devices

- *Impella*
    - Intracardiac pumps
    - Produce nonpulsatile, axial flow designed to pump blood from the LV into the ascending aorta
    - Different Impella products
        - Impella 2.5 L/min
        - Impella Cardiac Power (4.0 L/min)
        - Impella 5.0 L/min
        - Also have an Impella Right Percutaneous that can be used to treat right heart failure

    - Inserted percutaneously via the femoral artery (can also be inserted via the axillar artery) and advanced retrograde across the aortic valve; Impella 5.0 L/min requires surgical cut down
    - Impella devices entrain blood from the LV to pump into the aorta in series – unloads the LV and reduces myocardial oxygen consumption and demand
    - Ultimately decreases cardiac workload
    - Contraindications
        - Aortic valve disease
        - Mechanical aortic valve
        - LV thrombus
    - Literature
        - 2 small RCTs comparing Impella with IABP
            - Impella had higher cardiac index at 30 min after implantation
            - 30-day mortality roughly the same
        - More recent study from Impella Registry in patients with cardiogenic shock undergoing PCI – Impella 2.5 pre-PCI had reduced mortality compared with post-PCI implantation
        - Several other single-center, nonrandomized retrospective studies have shown more favorable outcomes in patients treated with Impella 5.0
- *TandemHeart*
    - Continuous-flow centrifugal extracorporeal assist device
    - Takes oxygenated blood from the left atrium and returns it to the femoral artery
    - Inflow cannula is inserted percutaneously via the femoral vein and advanced into the left atrium
    - Procedure requires a cath lab and cardiologist experienced in transeptal puncture
    - Oxygenated blood is pumped through a femoral artery cannula at a rate of 3.5-5.0 L/min
    - Hemodynamic benefits include:
        - Near-systemic blood flow rates
        - Improved MAP
        - Reduced PAOP
    - Overall, it reduces cardiac workload by decreasing LV pressures and volume
    - Contraindications: intracardiac thrombus and VSD
    - Literature
        - A review of 117 patients with refractory cardiogenic shock despite IABP counterpulsation or high-dose vasopressor – TandemHeart improved hemodynamics significantly and was associated with a lower than expected 30-day mortality
        - 2 randomized studies comparing TandemHeart with IABP in patients with AMI complicated by shock
            - Each reported improved hemodynamic parameters but had more complications in TandemHeart
            - Neither study had change in mortality

- *ECMO*
    - VA-ECMO includes a nonpulsatile pump, heat exchanger, and membrane oxygenator allowing for full biventricular support and gas exchange
    - Peripheral cannulation via the femoral vein and artery or centrally with cannulation of the right atrium and ascending aorta
    - Reperfusion catheters are often placed to allow blood flow distal to the insertion sites
    - Removal of venous blood reduces cardiac preload; reinfusion of blood through the arterial cannula increases MAP by increasing both systolic and diastolic pressures
    - Evidence for ECMO in cardiogenic shock is scant – no RCTs comparing ECMO with pVADs
    - Recent meta-analysis of cohort studies found that patient treated with ECMO had a higher 30-day survival when compared with IABP but no difference when compared with pVADs

Contraindications to Percutaneous Mechanical Support Devices

- Severe PVD
- Significant aortic valve disease
- Inability to tolerate systemic anticoagulation

Complications of Devices

- Common complications as a result of large cannulas and systemic anticoagulation include:
    - Limb ischemia
    - Bleeding
    - Vascular injury
    - Infection
    - Thromboembolic events
    - Hemolysis
- Hemorrhage
    - Can occur at multiple sites
    - Can have CNS and pulmonary hemorrhage
    - One of the most devastating complications of ECMO
- Renal complications are also very common
    - Incidence of AKI is as high as 80%
    - Many progress to renal failure requiring CRRT
- Impella
    - Devices associated with the most hemolysis**;** reducing device speed may reduce degree of hemolysis
    - Rarely, Impella devices have been associated with LV perforation

    - Requires close monitoring as migration can occur
- TandemHeart and ECMO most often associated with limb ischemia, bleeding, and vascular injury
- TandemHeart – can also be complicated by residual atrial septal defect due to transseptal approach
- ECMO
    - If native function is poor, ECMO output perfuses both cerebral and coronary circulation
    - As cardiac function recovers, a watershed mixing point can develop opposite to the ECMO flow
    - Supplying the heart with poorly oxygenated blood from the lungs could lead to hypoxemia to the upper half of the body – "Harlequin Syndrome'
    - Oxygenation of the cerebral and coronary beds can be checked by sampling the Right radial artery

Device Selection?

- Studies to date demonstrate improved hemodynamics but no clear survival benefit
- Also lack of uniformity among professional guidelines
- Once decision to use mechanical support, device should be inserted without delay to prevent further decompensation
- Definitive evidence for choice of device doesn't exist
- Selection should include assessment of familiarity, cost, consideration of R heart failure, degree of support needed, institutional capabilities