Mechanical Circulatory Assist Devices

Somshekar Ganti

Definition

Devices used to provide circulatory support during various clinical situations where the heart is not able to pump blood through the body.

Acute –cardiogenic shock, post cardiac surgery

Chronic – chronic heart failure

Importance

- CHF still on the rise, 1in 5 risk of developing CHF in their lifetime
- Early hemodynamic stabilisation with MCS devices can have significant impact on clinical outcomes
- Lack of donor organs for transplant means need for MCS devices

indications

- Three types
  - Bridge to recovery
  - Bridge to transplant
  - Bridge to Bridge

- Congestive heart failure
  - Post MI
  - Post cardiotomy
  - Primary conditions

General Indications

Acute setting

- Pulmonary capillary wedge pressure of > 20mmHg
- Systolic blood pressure < 80mmHg
- Cardiac Index < 2.0 litres/min/ m^2
- In the setting of maximal inotropic support

  Milrinone >0.5 µg/kg/min and

  Dobutamine > 5µg/kg/min

Indications

In Chronic setting

- Low cardiac output state despite maximal medical therapy
- end-organ failure is imminent (mixed venous saturations <60%)
- rising serum creatinine value in association with oliguria

Devices

- Counterpulsation - IABP
- Direct circulatory support
  - -Can be classified according to the need
  - Bridge to recovery (temporary)
    - Abiomed
    - Thoratec
  - Bridge to transplant (till transplant)
    - Abiomed BVS 5000
    - Thoratec extracorporeal
    - Heartmate vented Electrical
    - Novacor N100 LVAS

Devices

Bridge to Bridge (artificial hearts)

Cardiowest total artificial heart

Axial flow pumps

Heart mate II

DeBakey VAD

Jarvik 2000

Devices

- Two types
    1. Pneumatically driven
    2. Axial flow

IABP

- Kanrowitz first used in 1968
- 1out of 3 patients of cardiogenic shock post MI survived
- Now used in an estimated 70000 patients annually
- Main effect of IABP is
  - Increase in coronary perfusion pressure
  - Decreased left ventricular after load

IABP

- Placed percutaneously
- Ideally balloon tip should lie beyond the left subclavian or 2nd intercostal space
- Traditionally used in
  - Cardiogenic shock
  - Uncontrolled anginal pain
  - Post cardiotomy low cardiac output
  - Other indications
    - Post MI VSD,MR,
    - severe LMS lesions
    - difficult angiplasties,stents and high risk surgeries

IABP

- Contraindications

  AR, Severe PVD, Bleeding diathesis

Complications

Average reported 12.9-29%

Life threatening complications rare

Limb ischemia commonest (9-25%)

Pneumatic devices

- Contain polyurethane chambers and mechanical valves
- Inflow and outflow through atrial or ventricular cannulae and connections with dacron grafts
- Aortic valve and Pulmonary valves might have to be closed temporarily to prevent AI/PI and loss of C.O.
- Cannulae exit skin and connected to an external device
- Usually temporary devices – bridge to recovery or transplant

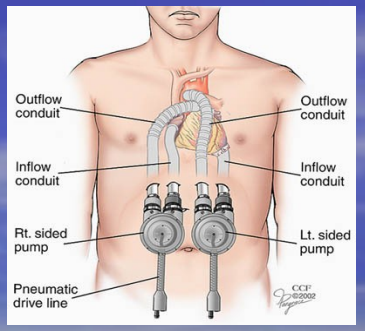
Abiomed

- Abiomed – is a dual chamber temporary external pulsatile VAD composed of smooth surfaced polyurethane bladders and trileaflet valves
- Can be used as RVAD, LVAD or BiVAD
- Inflow is from RA or LA / RV or LV – atrial cannulae or ventricular cannulation
- Outflow into Pulmonary artery or Aorta

Abiomed

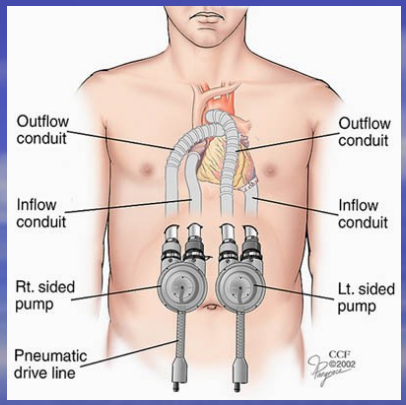
- Abiomed requires systemic heparinisation
- Requires minimal setup and adjustment to initiate and maintain support
- Less expensive than other devices
- Not for longterm use – needs replacement in 7-10 days if no recovery
- When used as RVAD can provide CVVH as renal replacement without additional access
- No need for CPB

Thoratec



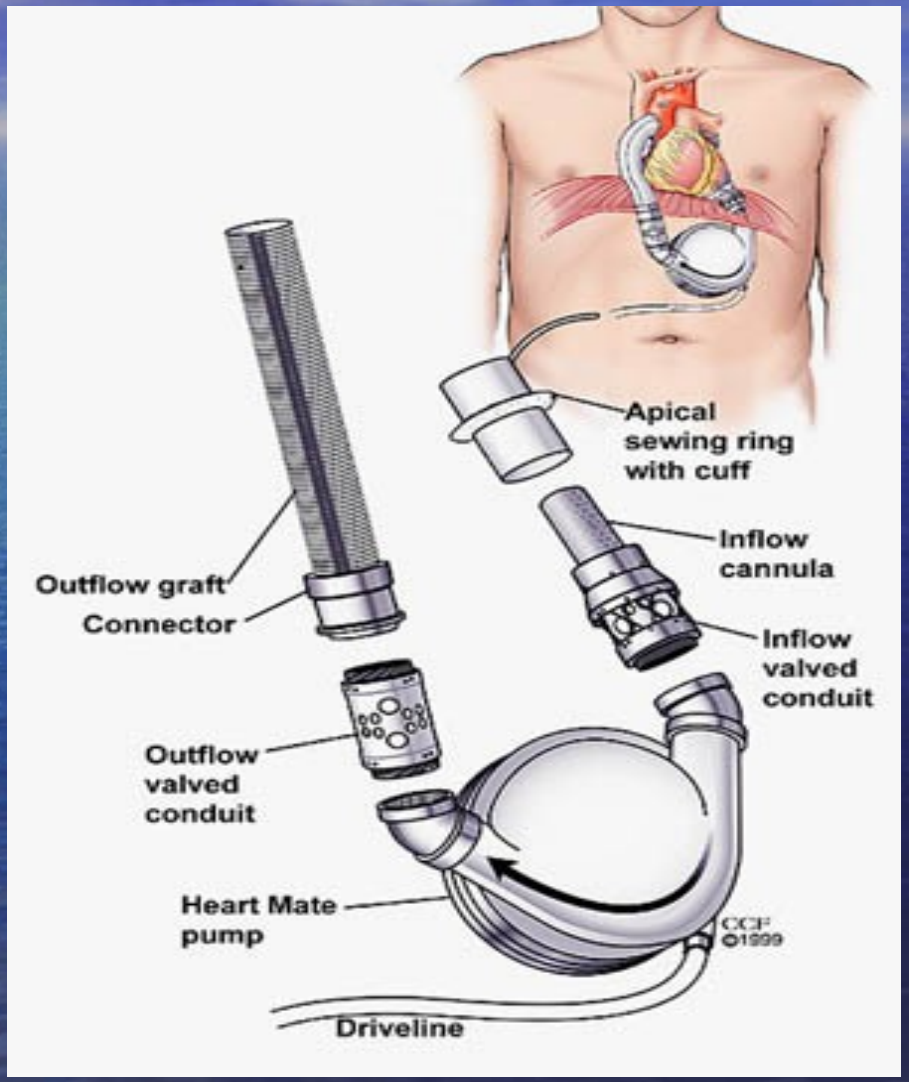
- Is composed of a rigid plastic case containing an elastometric blood pumping sac derived from a proprietary polurathane multipolymer (Thoralon)
- Can be used as RVAD, LVAD, BiVAD
- The blood sac is compressed by air from a pneumatic drive console
- Mechanical Bjork-Shiley valves in inflow and outflow ports

Thoratec



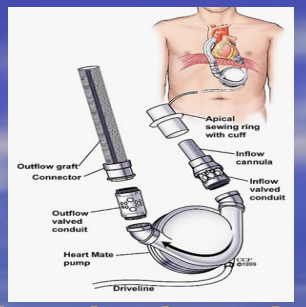
- The pump has a stroke volume of approx 65mls and is capable of C.O of 6.5 L/min at a pump rate of 100 beats/min
- Atrial and ventricular inflow cannulae available

Heartmate



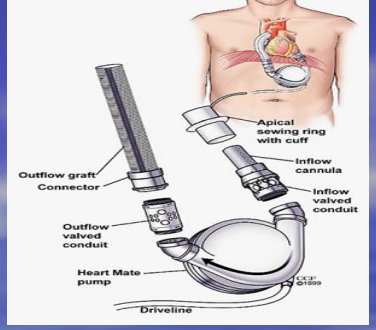
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Heartmate vented electrical LVAD



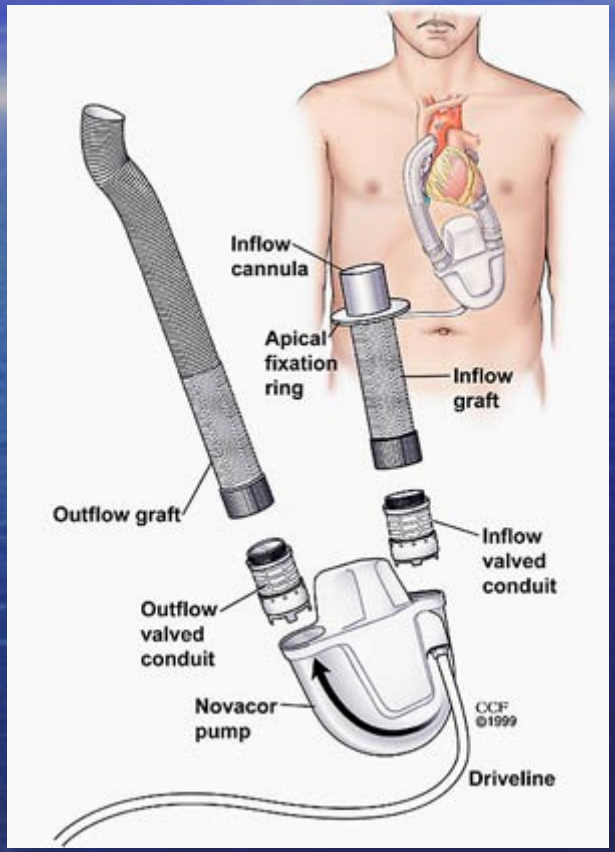
- Is a longterm, implantable left sided device
- Is a single pusher plate device
- Maximum stroke volume – 85ml
- Implanted through a median sternotomy
- Inflow cannula in ventricular apex and outflow into aorta
- Pumping chamber in pre-peritoneal pocket after dividing linea alba
- Drive line is brought out through a separate incision

Heartmate



- The length of outflow tube is kept to the minimum (upto 13 cm)
- Post operatively device migrates inferiorly and displaces outflow graft, therefore ample length should be left
- Oval punch hole in aorta – outflow sutured to this
- Strict hemostasis
- Dearing – trendelenberg's position, volume loaded, hand pumping, field flooded with saline, TOE to look for residual air

Novacor ® Implantable



Novacor LVAS

- Is a long term implantable left-sided device
- Implantation technique similar, the device is implanted in preperitoneal pocket

Cardiowest

- Is the only total artificial heart approved by FDA
- Pneumatically driven
- Implanted in orthotopic position
- Rigid pump housing that contains dual spherical polyurethane chambers
- A 4 layer polyurethane diaphragm ejects upto 70mls of can generate 6-8 L/min C.O.
- Inflow and outflow have dacron tubes with Medtronic mechanic valves

Cardiowest

- Ventricular chambers are anastamosed to native atrial cuffs and outflows to the great vessels
- Dual pneumatic drivelines exit transcutaneously to an adjacent control system, which monitors pump pressures and performance
- Antiplatelet and anticoagulation treatment required

Axial Flow Pumps



- Represent latest generation of assist devices
- Can provide full cardiac support in a much smaller pump with fewer moving parts and less blood contacting surfaces
- Nonpulsatile flow
- No difference in outcomes
- Weigh 53 – 176 gm and can generate 10 L / min C.O.

Axial Flow Pumps



- Heartmate II, DeBakey VAD, Jarvik 2000
- All have similar features
- Most patients maintain native cardiac output hence not totally nonpulsatile
- If device fails replacement is the only option
- DeBakey and Heartmate – median sternotomy; Jarvik – thoracotomy (6th intercostal space)
- Apical cannulation and great arteries
- The pump is placed intraventricularly
- Outflow graft sutured to descending aorta with a side biting clamp.

Surgical considerations

- Transplant eligible patients with acute instability, or chronic deterioration and impending organ failure despite maximal medical therapy.
- Some patients may be candidates for myocardial revascularisation, aneurysmorrhaphy or valvular repair / replacement but have developed acute deterrioration in hemodynamics

Surgical implantion

- CPB needed for all except Abiomed
- Atrial cannulation
- Ventricular cannulation – teflon pledgeted purse string suture
- If there is AR / MR appropriate repair is done (suturing of leaflets, dacron / preicardial patch for aortic valve; Alfieri stitch for mitral)
- Deairing and pump commenced

Outcomes

- Operative mortality with LVAD – 20%
- 5% mortality at the time of removal
- Hospital discharge after transplant is 75%
- Predominant cause of death is MOF and sepsis.
- Right heart failure is common in upto 50% of patients receiving LVAD
- Post op neurologic complications more common with Novacor LVAS

Outcomes

- Inflow valve regurgitation develops with Heartmate LVAD – leading to volume overloading of LV – pulmonary edema

evidence

- REMATCH study rose et al
  - 129 patients randomised to LVAD or medical therapy
  - 48% reduction in risk of death from any cause in the surgical group
  - Risk of serious adverse events 2.5 times higher in the surgical group

ECMO

- Separate topic

Conclusion

- Current devices are only bridge to transplant – have high rates of infection and stroke
- Remain expensive and are not cost effective
- Not ideal for destination therapy
- Future devices – small, durable, implantable, long battery life, less infection risk.