Ventricular Assist Device

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What is a Ventricular Assist Device (VAD)?

- Electromechanical device for assisting cardiac circulation
  - Used to partially or completely replace the function of a failing heart, takes over 90% of what your heart should be doing
  - Connects to an external power base unit or battery pack
- Short-term use - for patients recovering from heart attack or cardiac surgery
- Long-term use – for patients suffering from advanced congestive heart failure, used as a bridge to transplantation while awaiting a heart transplant
- Designed to assist the right (RVAD) or the left ventricle (LVAD), or both (BiVAD)
  - Bulky – smallest weighing 1 pound and about 3 inches
RVAD and LVAD

- LVAD – most common; sometimes applied as a destination therapy (patient shouldn’t undergo transplant), or applied as a bridge to recovery
  - Bridge to transplant (BTT) – patients awaiting heart transplants
  - Destination therapy (DT) – patients too old or not suitable for transplantations due to other medical conditions

- RVAD – necessary when pulmonary arterial-resistance is high
History

- 1965 – first cardiac transplantation
- 1990 – Pulsatile VADs – 1st generation
- 2000 – continuous flow VADs – 2nd generation
- 2003 – FDA approval: bridge to transplantation
- 2010 – FDA approval: destination therapy
- 2015 – Electromagnetic VADs – 3rd generation
First Generation VAD

- Pneumatically or electrically driven membrane pumps generating pulsatile flow with artificial heart valves as inlet and outlet
  - **Disadvantages** - large size, noise emission, infections of cannulas, malfunction due to tears in the membrane, degradation of valves
In 2000 – development of continuous flow centrifugal pump devices
- Designed only for intrathoracic implantation, only LVAD was possible, as other devices were too large
- Impeller-propeller surrounded by a metal case – increased the durability up to a min. of 5 years
- Improved patient outcome – reduced size and susceptibility for infections, noise reduction
Third Generation VAD

- Another significant reduction in size (golf ball) – now LVAD and BiVAD implantations are possible
  - Radial pump with magnetic and hydraulic positioning
  - Estimated durability of 10 years
  - Takes over complete circulatory support
  - 10L of blood per minute
  - Inserted in pericardial space, attached to apex of left ventricle, outflow is attached to ascending aorta
    - Blood flow – into left ventricle -> inflow cannula -> impeller -> outflow -> circulates body
    - Implant pump connects to an externally worn controller powered by batteries, operates pump.
    - Up to 17 hour battery life
    - External portion is replaceable without need for whole pump replacement
Indications

- Fatal cardiac arrhythmia, end stage of heart failure
- Successful long term results are highly dependent on the timing of implantation
  - If too early, heart is not fully exhausted
  - If too late, outcome may worsen due to secondary organ damage caused by prolonged heart failure
Complications/Side Effects

- Clotting – due to blood flowing over a non-biologic surface, need for anticoagulation
- Infection – due to reduction of leukocytes, treatment is difficult
- Bleeding - most common early complication
  - Monitoring the bleeding in the early hours after implantation, if needed, evacuate blood from around heart and lungs, preventing need for reoperation to wash out clot that could compress device features
- Non-reversible lung, liver, and kidney damage, severe right heart failure
- **Challenge**: determining whether patient needs right ventricular support as well
  - The sicker the patient, higher the likelihood of right ventricular failure
  - Up to 20-40% show RV failure after LVAD implantation
Future

- With decreasing of heart transplants due to limited donor organs, the importance of these devices is continuously increasing
- Technical improvements – significant size reduction, performance optimization, enhanced clinical applicability
- Improved durability and almost wear free components
References