



# Mechanical Circulatory Support in Heart Failure Patients

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# Mechanical Circulatory Support (MCS)

- no disclosure

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# Learning Objectives

Fundamentals of Mechanical Circulatory Support technology

MCS indications

Types of MCS for short term and long - term support

Function and usage of each MCS devices

Future of MCS



# What is mechanical circulatory support (MCS)?

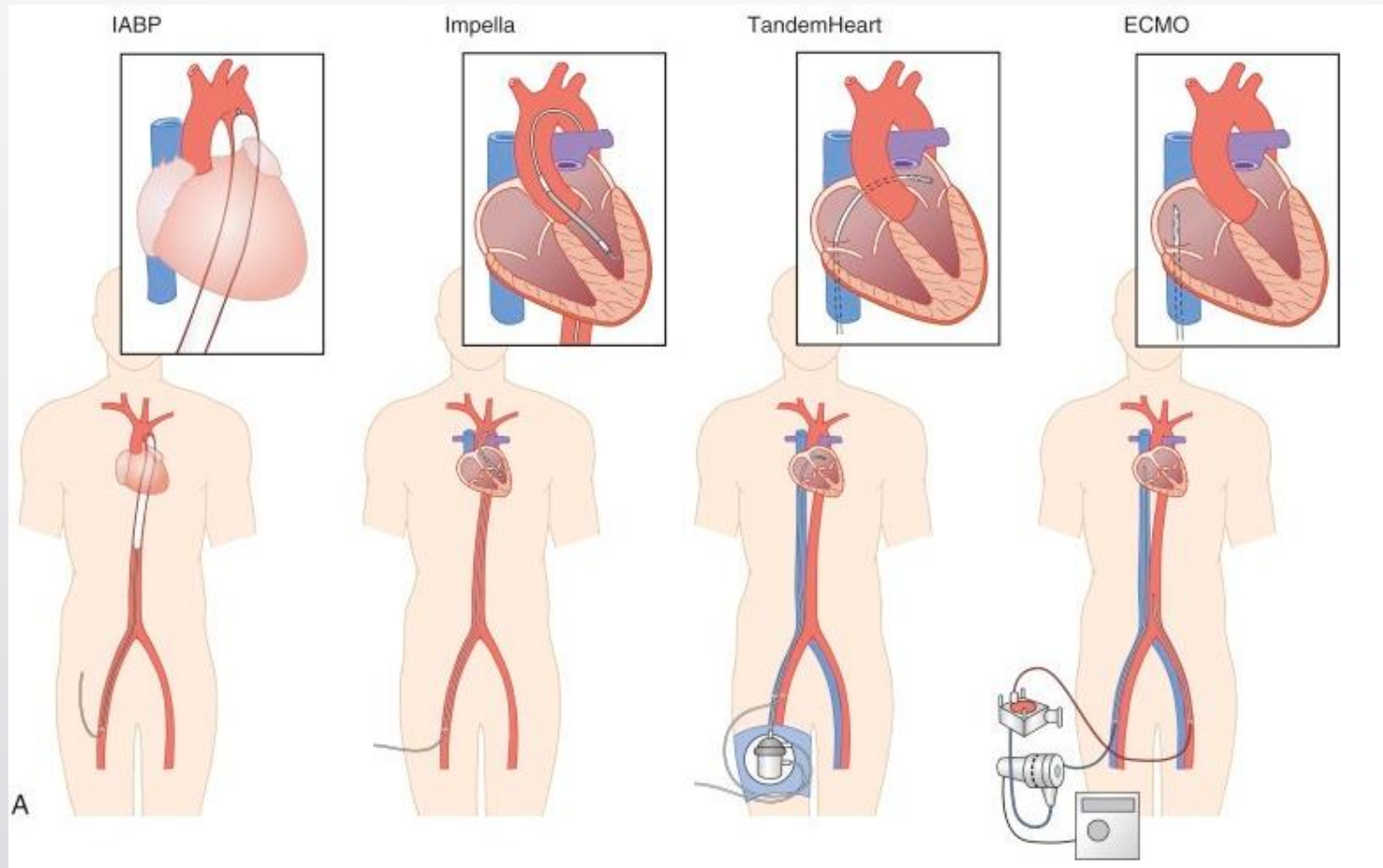
- Patients with advanced heart/ lung failure or acute cardiogenic shock need mechanical support to keep their heart pumping enough blood. Mechanical circulatory support (MCS) devices step in – either temporarily or permanently – to either supplement or replace the functions of the failing heart or lungs.



# Function and Usage of Mechanical Circulatory support

- During cardiogenic shock in acute MI – short term MCS
- For end stage heart failure patients – Long term MCS
- Restore cardiac output to preserve end organ perfusion
- Off load the LV
- Optimize balance between myocardial oxygen supply and demand
- Allow time for recovery of ischemic, stunned, hibernating myocardium
- Short term MCS choices;: IABP, ECMO, pVAD
- Long term MCS choices: LVAD, TAH

# Temporary MCS





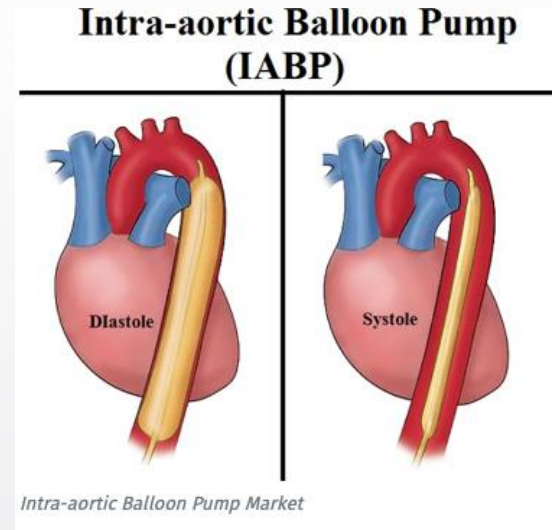
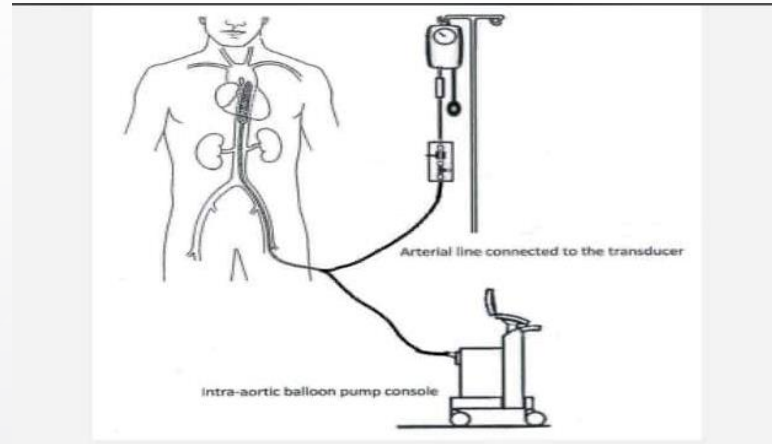
# Percutaneous VADs

	IABP	TandemHeart	Impella	ECMO
Mechanism	Pneumatic	Centrifugal	Axial	Centrifugal
Insertion	Retrograde 7-9F cath into desc aorta via FA	21F cath inflow into LA via FV and TS, 17F cath outflow into FA	12F cath retrogradeX AoV via FA	22F inflow cath into RA via FV, 18-22F outflow into desc aorta via FA
Difficulty of insertion	+	++++	+++	++
Circulatory support	(+ CO – 0.5 L/min)	+++ CO – 3.5-4.5 L/min	++ CO – 2.5 L/min	++++ CO - $\geq$ 4.5 L/min
Implantation time	10 min	125-65 min	10-25 min	10-15 min
Hemolysis	0	++	++++	+++
Bleeding	+	+++	++	++++
Approval duration		6h	6h	



## IABP

- AutoCat2wave IABP (Teleflex) and Datascope (Maquet) are two common vendors in US market
- Indications- High Risk CABG patients (pre-op)
- High Risk PCI patient (pre-op)

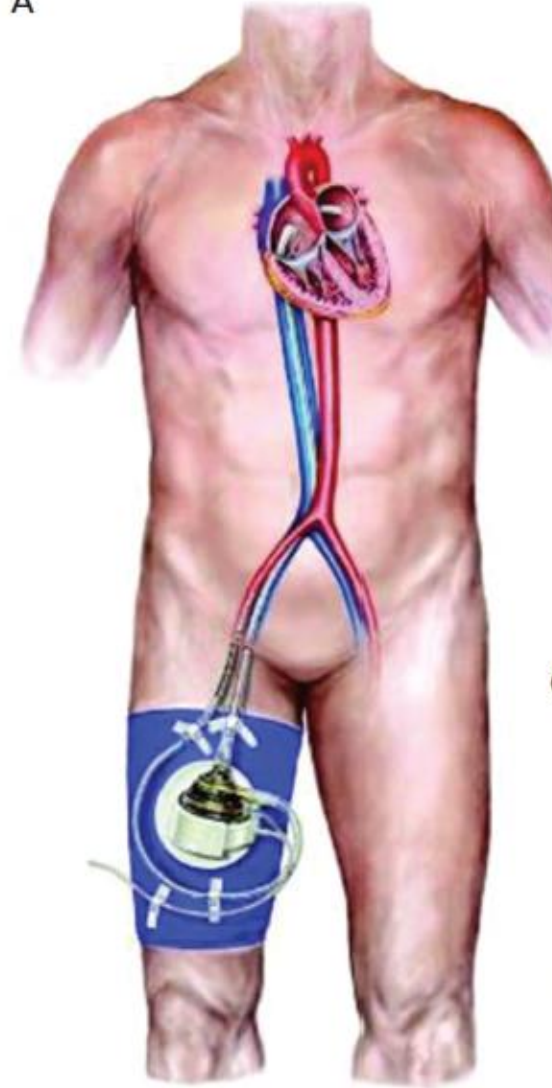




# Tandem Heart

- Made by Cardiac Assist, (LivaNova)
- External centrifugal pump – up 4L/min
- Inflow cannula insert via femoral vein and up to inferior vena cava, trans-septal puncture. Draw blood from LA bypass R heart.
- Outflow cannula insert into femoral artery and advance to common iliac artery.
- Indications – cardiogenic shock, High Risk PCI, VT, Bridge refractory HF, RV support

A



B



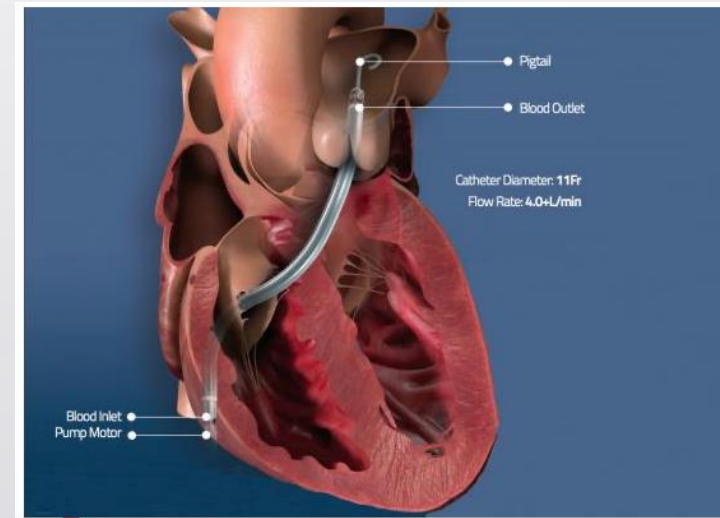
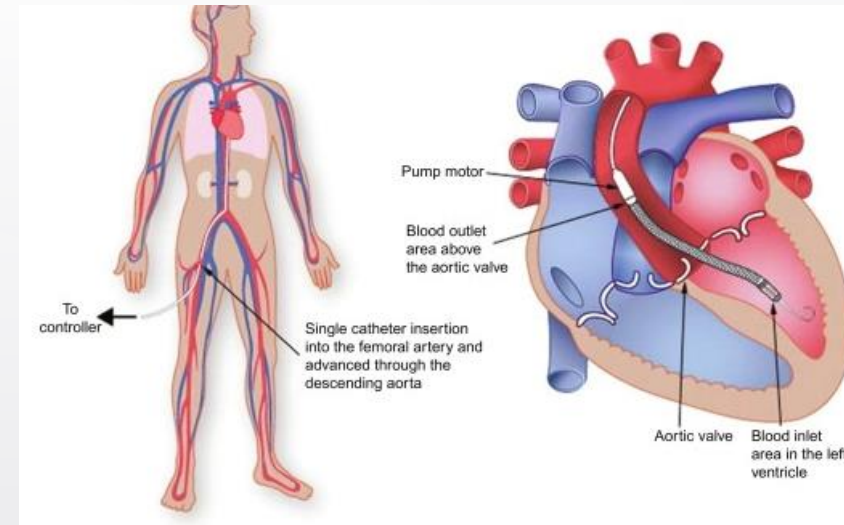
C



TandemHeart (A) consists of a 21-Fr inflow cannula in the left atrium after femoral venous

# Impella - Percutaneous VAD

- Manufactured by Abiomed.
- Small catheter inserted into the femoral artery and advanced through the descending aorta.
- Microaxial flow pump (2.5L/min - 5L/min) with blood inflow from LV and outflow to Asc Aorta.
- Requires anticoagulation
- New device is Impella RP can provide RV support.
- Good for patients ONLY have poor low CO or procedural VT ablation.





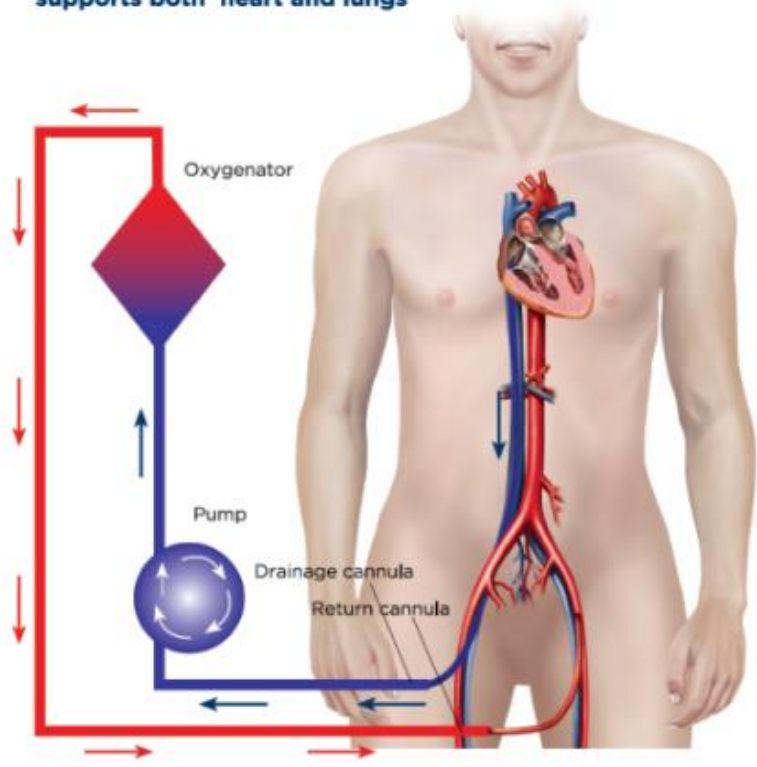
## VA or VV ECMO

- VA ECMO- Venous to Arterial – Drain venous blood – Pump (oxygenator)- Arterial.
- Provide full CO and lung support. Basically bypass heart and lung.
- Can be used for cardiogenic shock or massive PE wait for recovery.
- Can be used for bridge to heart/lung transplant or implantable VADs.
- VV ECMO – drain venous blood – oxygenator –venous. Bypass Lung.
- VV ECMO – Use for ARDS or COVID 19 for bad lungs but good heart.



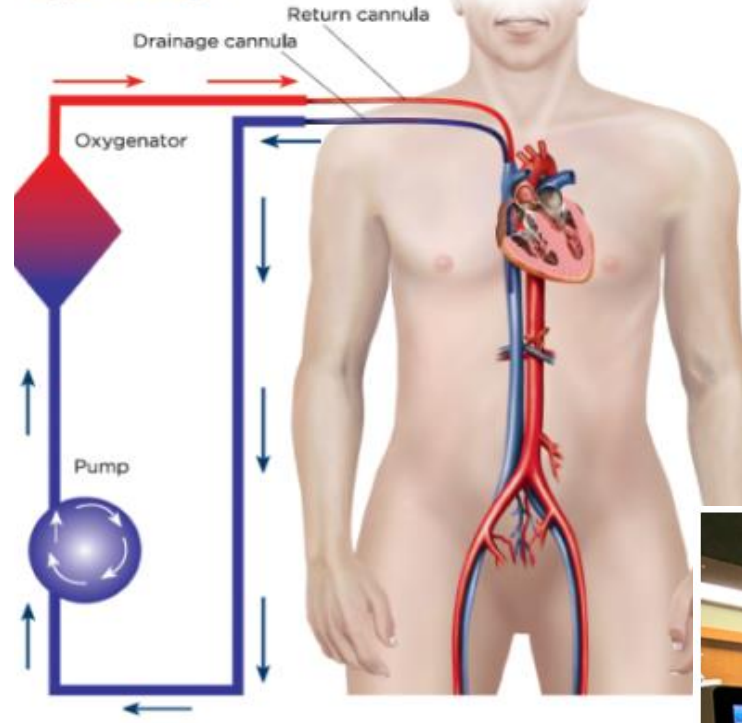
## Veno-arterial (VA) ECMO

supports both heart and lungs



## Veno-venous (VV) ECMO

supports lungs



An ECMO machine in action in an intensive care unit. (Getty Images: Akiromaru)

ECMO manufacturers market in US are Medtronic, Maquet (Getinge), Sorin and LivaNova.



# COVID-19 cases on ECMO in the ELSO registry




## COVID-19 ECMO counts by ELSO Chapter

	Total (n)	Still on ECMO	Completed ECMO	Discharged alive/dead	Transferred out on ECMO
All ELSO	2379	379	2000	1790	17
North America	1511	247	1264	1130	13
Europe	552	50	465	465	3
Asia Pacific	49	13	36	29	0
Latin America	114	36	78	66	0
SWAAC	153	33	120	100	1

\* not reporting cases where n < 5





## Long Term MCS –Left ventricular assist devices (LVAD)

- Why long term MCS devices?
- In 2019 UNOS, >4000 waiting for Heart transplant, 1400 waiting for lung transplant, 43 waiting Heart and Lung.
- Number of heart donors didn't not increase but number of patients in waiting list is increasing since 1990.
- Increased life expectancy of heart failure patients
- Increased number of patients with NYHA IV heart failure



# Implantable MCS

- Long term or permanent MCS is LVAD
- HeartMate XVE (Thoratec)–first generation
- HeartMate II (Abbott) and HeartWare (Medtronic) - second generation
- HeartMate 3 (Abbott) – new generation



# Goals of MCS

- Bridge to transplantation – mechanical support of heart/lungs for patients awaiting transplant.
- Bridge to Recovery – mechanical support allowing patients to recover sufficient myocardial or pulmonary function to allow device explantation.
- Bridge to decision- mechanical support for patients whose candidacy for heart or lung transplantation remains to be determined.
- Destination Therapy.

## Patient selection for MCS according to INTERMACS

**Table 13.2 INTERMACS (Interagency Registry for Mechanically Assisted Circulatory Support) stages for classifying patients with advanced heart failure**

INTERMACS level	NYHA Class	Description	Device	1y survival with LVAD therapy
1. Cardiogenic shock "Crash and burn"	IV	Haemodynamic instability in spite of increasing doses of catecholamines and/or mechanical circulatory support with critical hypoperfusion of target organs (severe cardiogenic shock).	ECLS, ECMO, percutaneous support devices	52.6±5.6%
2. Progressive decline despite inotropic support "Sliding on inotropes"	IV	Intravenous inotropic support with acceptable blood pressure but rapid deterioration of renal function, nutritional state, or signs of congestion.	ECLS, ECMO, LVAD	63.1±3.1%
3. Stable but inotrope dependent "Dependent stability"	IV	Haemodynamic stability with low or intermediate doses of inotropics, but necessary due to hypotension, worsening of symptoms, or progressive renal failure.	LVAD	78.4±2.5%
4. Resting symptoms "Frequent flyer"	IV ambulatory	Temporary cessation of inotropic treatment is possible, but patient presents with frequent symptom recurrences and typically with fluid overload.	LVAD	78.7±3.0%
5. Exertion intolerant "Housebound"	IV ambulatory	Complete cessation of physical activity, stable at rest, but frequently with moderate fluid retention and some level of renal dysfunction.	LVAD	93.0±3.9% <sup>a</sup>
6. Exertion limited "Walking wounded"	III	Minor limitation on physical activity and absence of congestion while at rest. Easily fatigued by light activity.	LVAD / Discuss LVAD as option	-
7. "Placeholder"	III	Patient in NYHA Class III with no current or recent unstable fluid balance.	Discuss LVAD as option	-

ECLS = extracorporeal life support; ECMO = extracorporeal membrane oxygenation; INTERMACS = Interagency Registry for Mechanically Assisted Circulatory Support; LVAD = left ventricular assist device; NYHA = New York Heart Association.

<sup>a</sup>Kaplan-Meier estimates with standard error of the mean for 1 year survival with LVAD therapy. Patients were censored at time of last contact, recovery or heart transplantation. Due to small numbers outcomes for INTERMACS levels 5, 6, 7 were combined<sup>610</sup>.





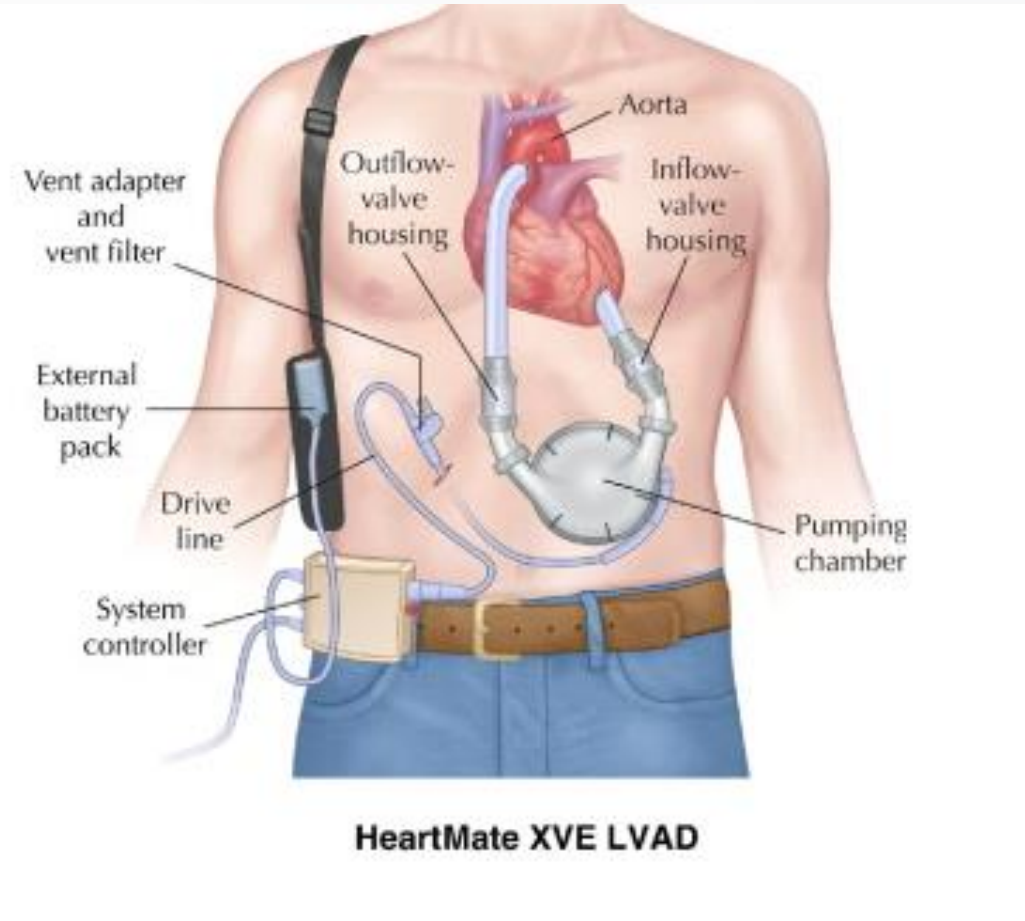
# REMATCH Trial

- Randomized trial of 129 patients (2001)– LVAD HeartMateXVE vs medical support.
- LVAD patients have longer survival and better quality of life
- Conclusions of REMATCH trial
- Improved survival
- Improved quality of life
- Significant morbidity and mortality of LVAD – infection and device failure



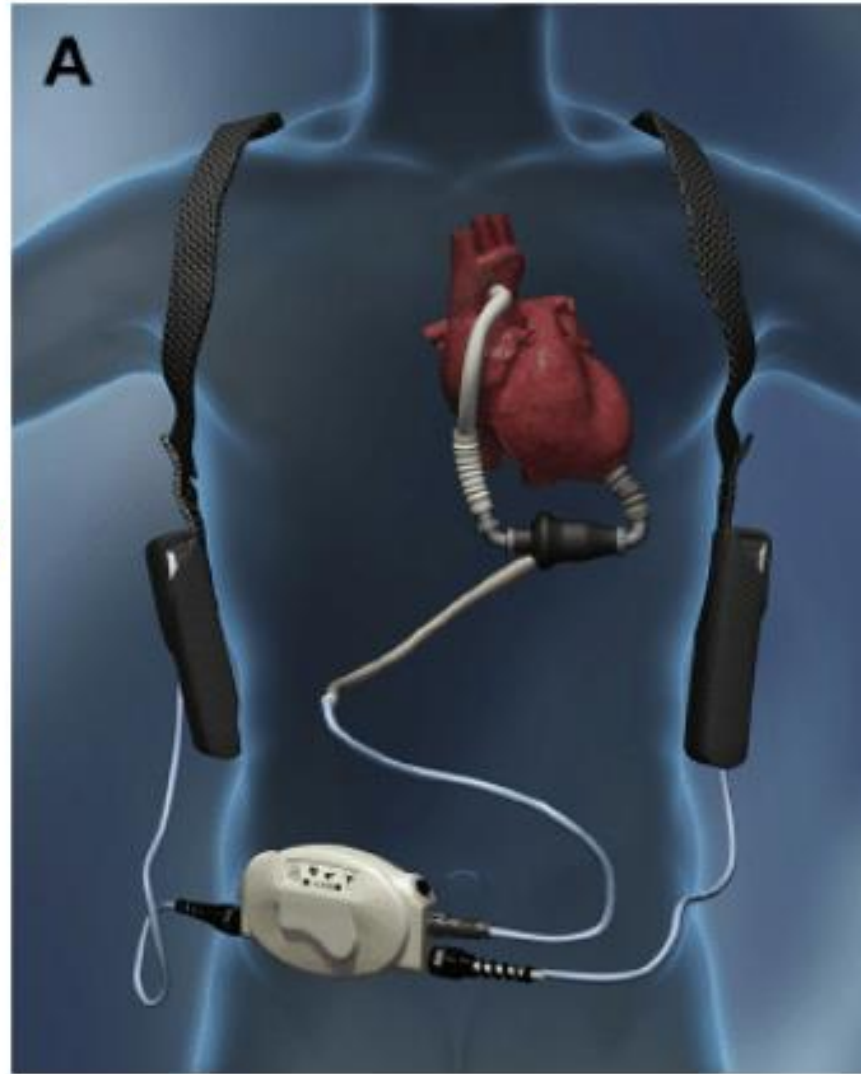
# HeartMate XVE

- First generation -HeartMate XVE (Thoratec)- volume displacement
- Median Durability 18.6 months.
- Probability of device exchange 73% at 2 years
- HM XVE was FDA approved for DT in 2002



# HeartMate II (Abbott)

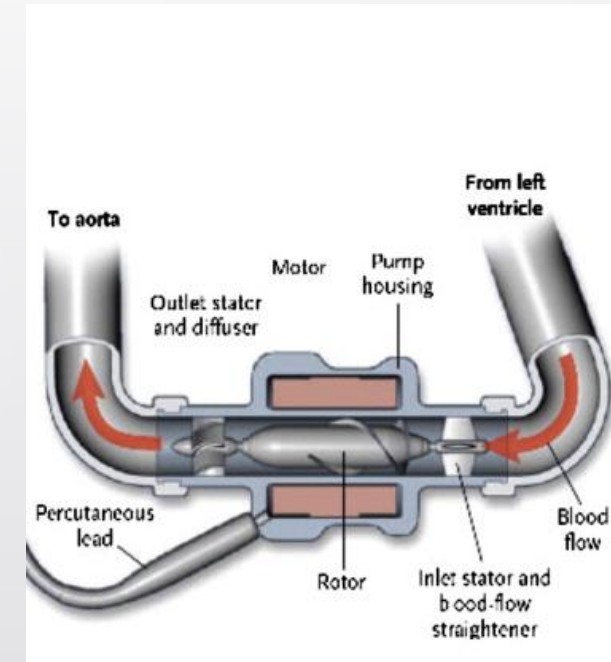
- FDA approval as in BTT 2008
- And DT in 2010
- Pump is placed beneath the apex of the LV, usually requiring a pump pocket,
- the outflow graft is anastomosed to the ascending aorta.
- The device is powered and controlled through a percutaneous driveline that is connected to an external controller. Power is supplied by two wearable batteries.



Second-generation LVAD. ( A ) Diagram of HeartMate II

# HeartMate II

- HeartMate II (Abbott)
- Axial blood pump
- The most commonly used LVAD >20,000 patients worldwide
- compare between HeartMate XVE (pulsatile flow pump) and HeartMate II (continuous flow pump) is more superior in term of safety and efficacy.

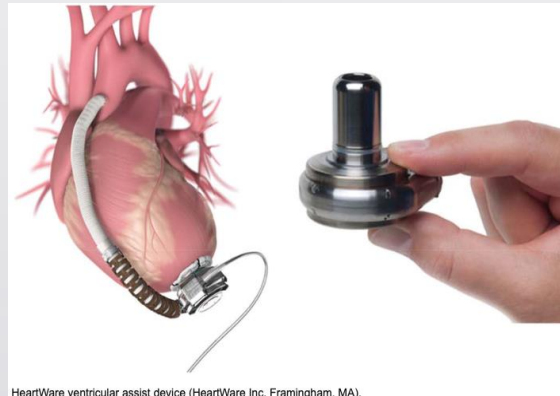
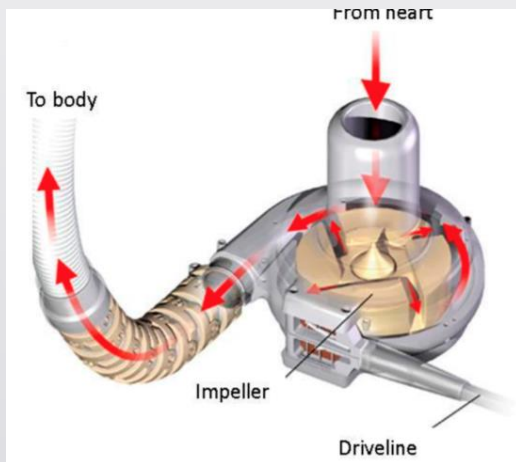


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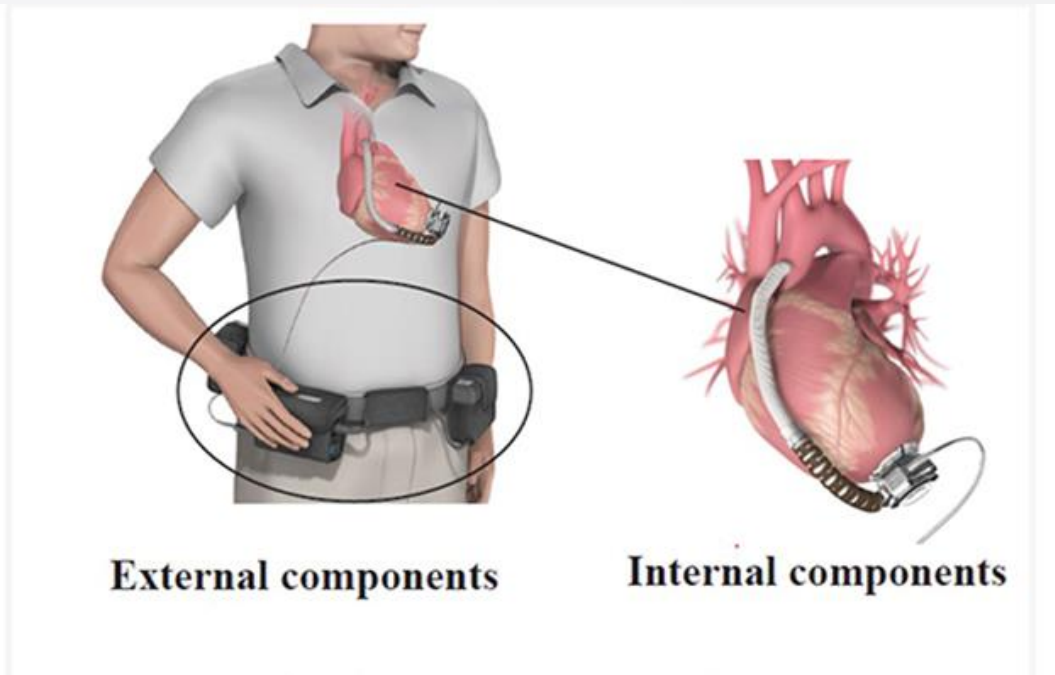


# Heartware

- FDA approved in 2012 as bridge to transplant
- Device sew in pericardial space at the apex of the heart and outflow tract attach to the ascending aorta.
- Is a centrifugal heart pump

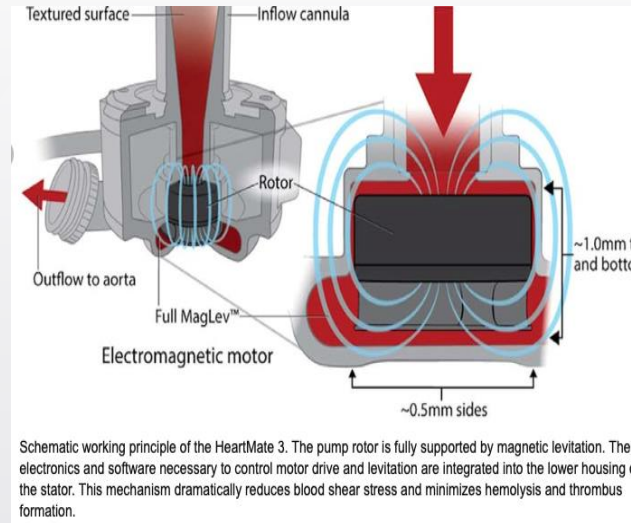


HeartWare ventricular assist device (HeartWare Inc. Framingham, MA).



# HeartMate 3

- HearMate3 (Abbott)
- Is the newer widely used LVAD
- Centrifugal magnetic levitated continuous flow pump that also engineer for intrinsic pulsatility.
- Design to enhance hemocompatibility and reduce shear stress on blood cells.
- MOMENTUM 3 Clinical trial aims to compare HeartMate 3 to HeartMate 2. HM3 is more superior than HM2



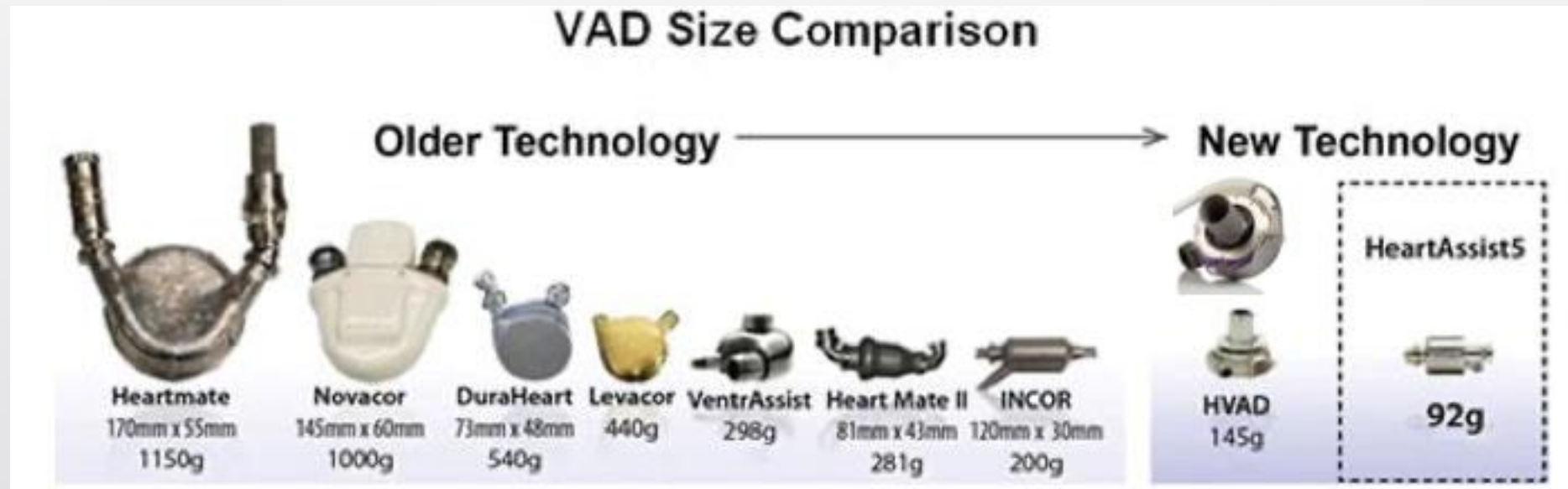




# Complications of LVADs

- LVAD or driveline infections
- Bleeding- GI bleed
- ventricular arrhythmias
- LVAD malfunction
- Pump thrombosis
- Neurologic complication- stroke
- Heart Failure- Right heart failure

# Future durable VADs





# Future MCS

- Next generation MCS with Novel flow mechanism, smaller and better hemocompatibility.
- Device able to automatically respond to changing hemodynamics and metabolic demands.
- TORVAD (Windmill Cardiovascular System)
- Neptune (Corwave)
- Novel Total Artificial Heart- BiVACOR, RealHeart and Carmat.



Thank You

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