Artificial Hearts

Presented by: Ahmed Osman & Sinan Yaseen

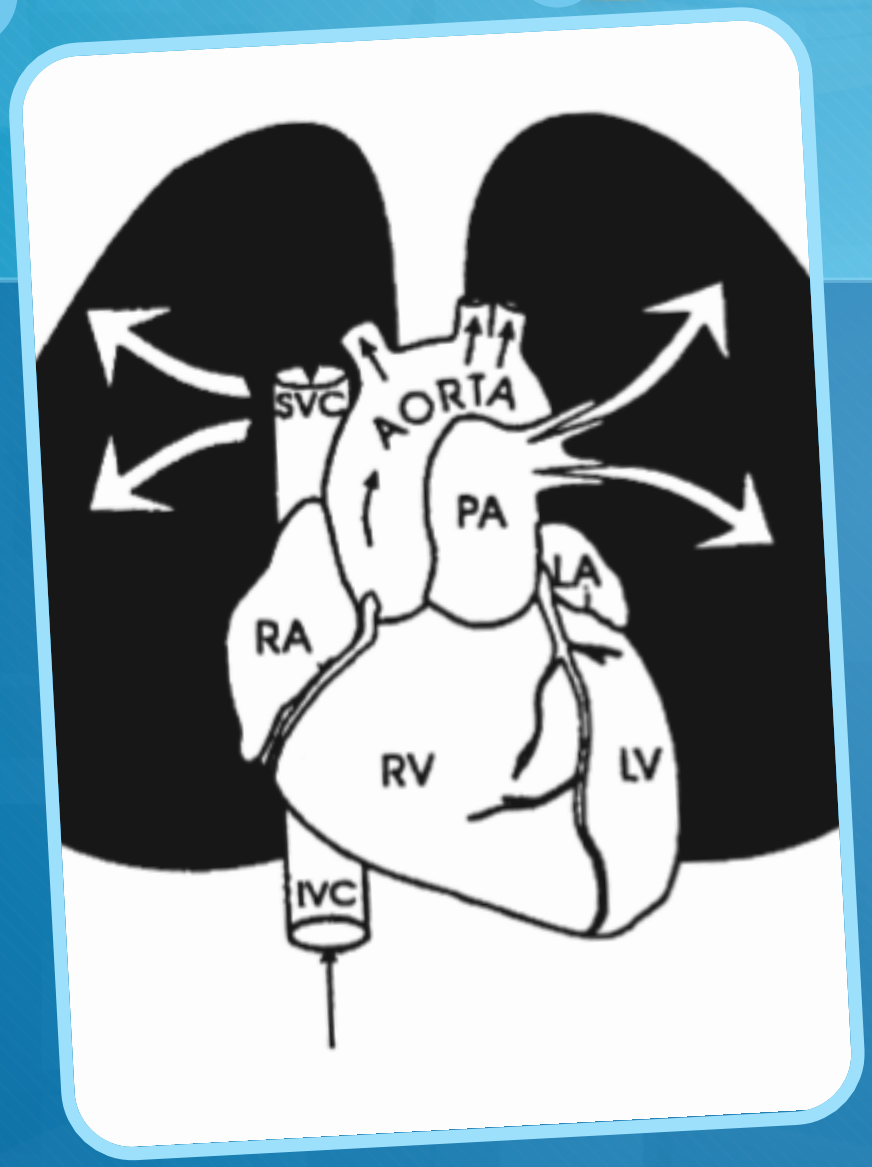
Overview

- Anatomy and function of the heart
- Reasons for heart failure
- Who needs artificial hearts?
- What is a Artificial heart
- History of the artificial heart
- Different Models of Artificial hearts
- Complications
- Future

THE HEART

- The heart is a muscular organ, which pumps blood around the body. It consists of four chambers:
- Left and right atria (blood receiving chambers).
- Left and right ventricles (the blood pumping chambers).
- Typical resting heart rate is 60-80 bpm
- Normal blood pressure is 90-120 mm Hg systolic and 60-80mm Hg diastolic

THE HEART



Blood within the left ventricle (left heart) is pumped into the aorta and on to the general body. Blood within the right ventricle (right heart) is pumped into the pulmonary artery and on to the lungs.

Blood from the general body is received via the superior vena cava (SVC) and the inferior vena cava (IVC) into the right atrium (RA). It then passes from the right atrium into the right ventricle (RV) and is subsequently pumped via the pulmonary artery (PA) into the lungs.

Blood from the lungs is received by the left atrium (LA) and passes into the left ventricle (LV) from where it is pumped via the aorta into the general body.

What is an artificial heart?

- Man-made device
- Implanted into the body and replaces a person's heart function.
- 2 types - TAHs and VADs

Why do we need artificial hearts?

- The number one leading cause of death in the entire world is heart failure.
- In the US alone, more than 700,000 people each year die from heart failure.
- Only about 2,000 individuals get a heart transplant each year.
- Many people die because of the lack of availability or there are no matchable donor hearts.
- Due to the scarce availability of transplantable hearts, artificial hearts was introduced.

Heart Failure

- Heart failure is a condition where the heart cannot pump enough blood throughout the body.
- Most cases involve the left side where the heart cannot pump enough oxygen-rich blood to the rest of the body.
- With right sided failure, the heart cannot effectively pump blood to the lungs where the blood picks up oxygen.

History of the artificial heart

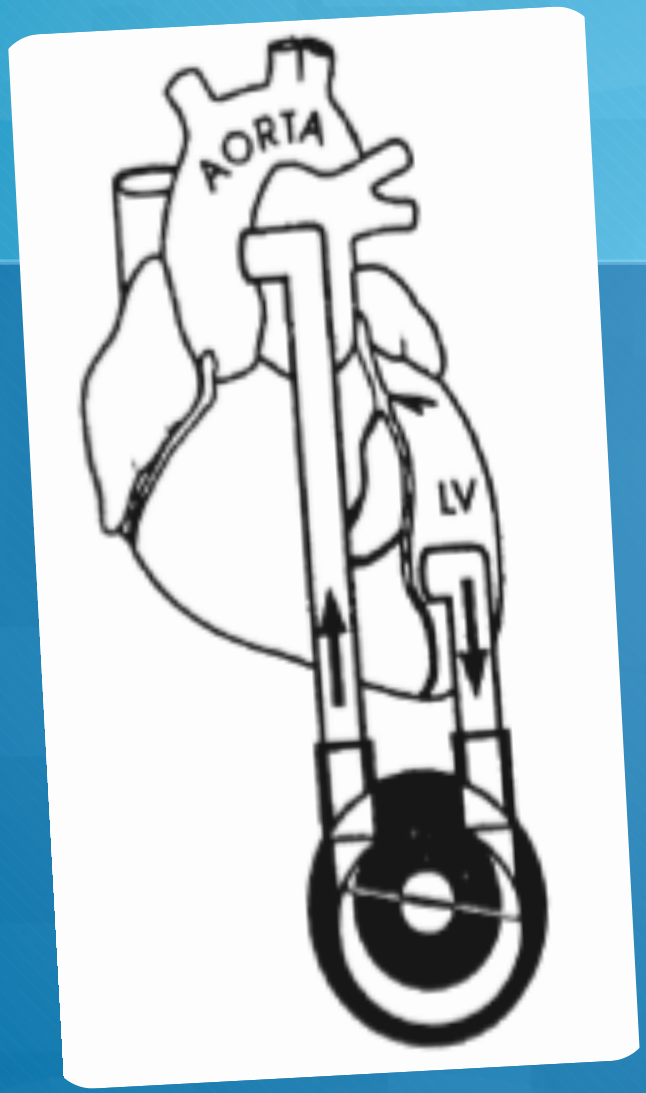
- 1953 – Invention of the first heart lung machine by John H. Gibbons Jr. which was the first step towards the artificial heart
- 1957 – First artificial heart implanted inside a dog (made from plastic)
- 1969 – First total artificial heart implanted inside a person
- 1970 – Left ventricular assist systems became mainstream (devices where made form polyurethane and plastic)
- 1986 – Jarvik – 7 heart recipient survived 20 months with heart
- 1994 – Battery powered LVAD available
- 2001 – AbioCor artificial implanted into patients
- 2010 - Man was implanted with an artificial heart while waiting for a heart. This heart could beat up to 9.5 liters per minute.

What is an artificial heart made of?

- The pump itself is made of a combination of metal and plastic and consists of a small pumping chamber lined by a special material that prevents blood clots from forming.
- The pumping chamber may be implanted within the body itself or may lie outside the body depending on the type of artificial heart being used.

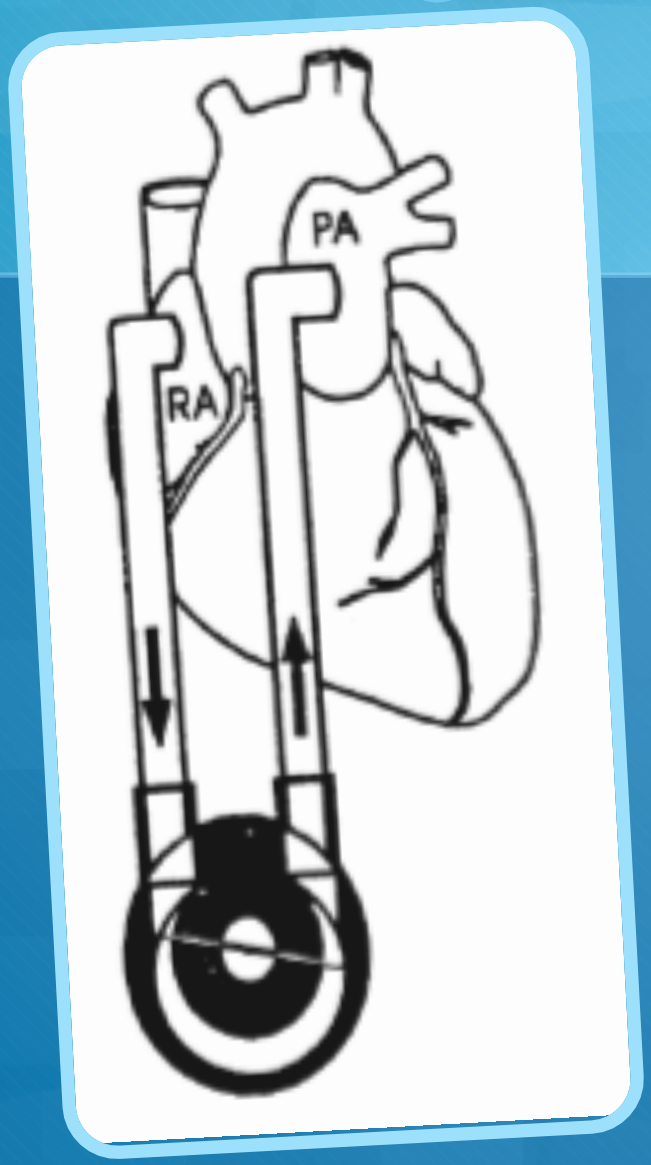
VAD's

- A VAD may be connected to a person in various ways to support the left heart, the right heart or both sides of the heart



Left Ventricular Assist Device (LVAD)

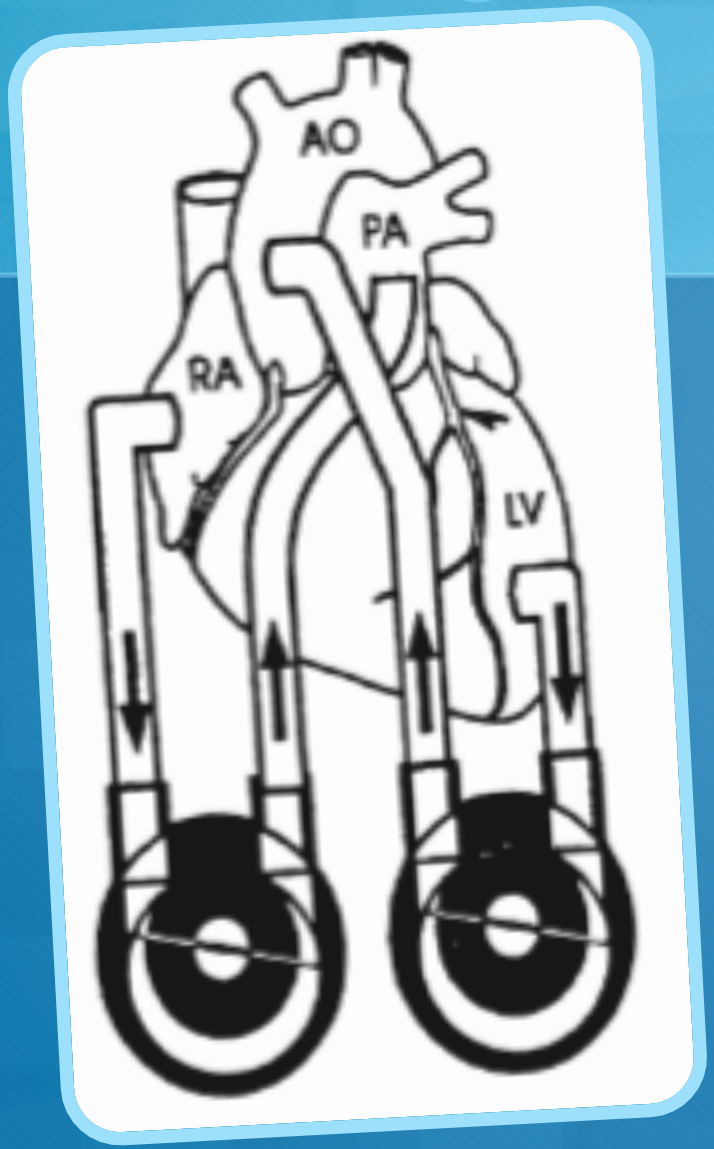
Blood is received into the device from the left ventricle (LV) and is pumped into the aorta.



Right Ventricular Assist Device (RVAD)

Blood is received into the device from the right atrium and is pumped into the pulmonary artery.

Biventricular Assist Device (BiVAD)



This is a combination of a left ventricular assist device (LVAD) and a right ventricular assist device (RVAD).

TAH – Total artificial heart

- Completely replaces the patients heart
- So patients heart is removed
- Many models
- Only recently has become achievable

How are TAH's Connected

- Total artificial connects by replacing the ventricles
- Ventricles are removed and artificial ventricles are connected
- Left artificial ventricle connect to left atrium and to aorta
- Right artificial ventricle connect to Right atrium and to pulmonary arteries
- There are slight variations between models

How does an artificial heart work?

- Blood enters the artificial heart from the left or right atrium and is then pumped into the aorta or pulmonary artery, depending on which side of the heart is being supported.
- The device is powered by either compressed air or electricity.
- A thin cable connects the pumping chamber to a control console from which the pump function is regulated.

For how long does an artificial heart work?

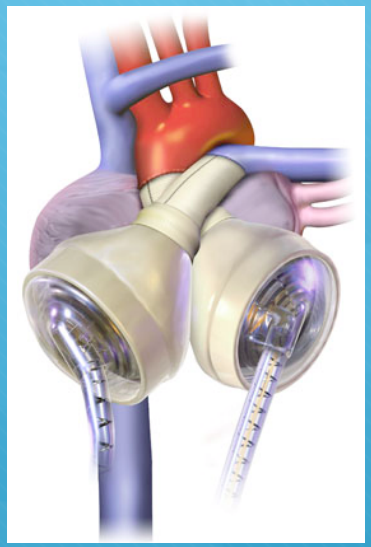
- Once the artificial heart has been implanted it usually remains in place and functioning until the person receives a heart transplant. This time may range from a few weeks to a year. The person receives a transplant when his or her medical condition has improved enough to make it safe to perform the transplant and a suitable donor has been found. During the transplant operation, the artificial heart is removed.
- Needs to be replaced due to wear and tear after up to 5 years

Types of artificial heart

3 types:

- Jarvick 2000

CardioWest

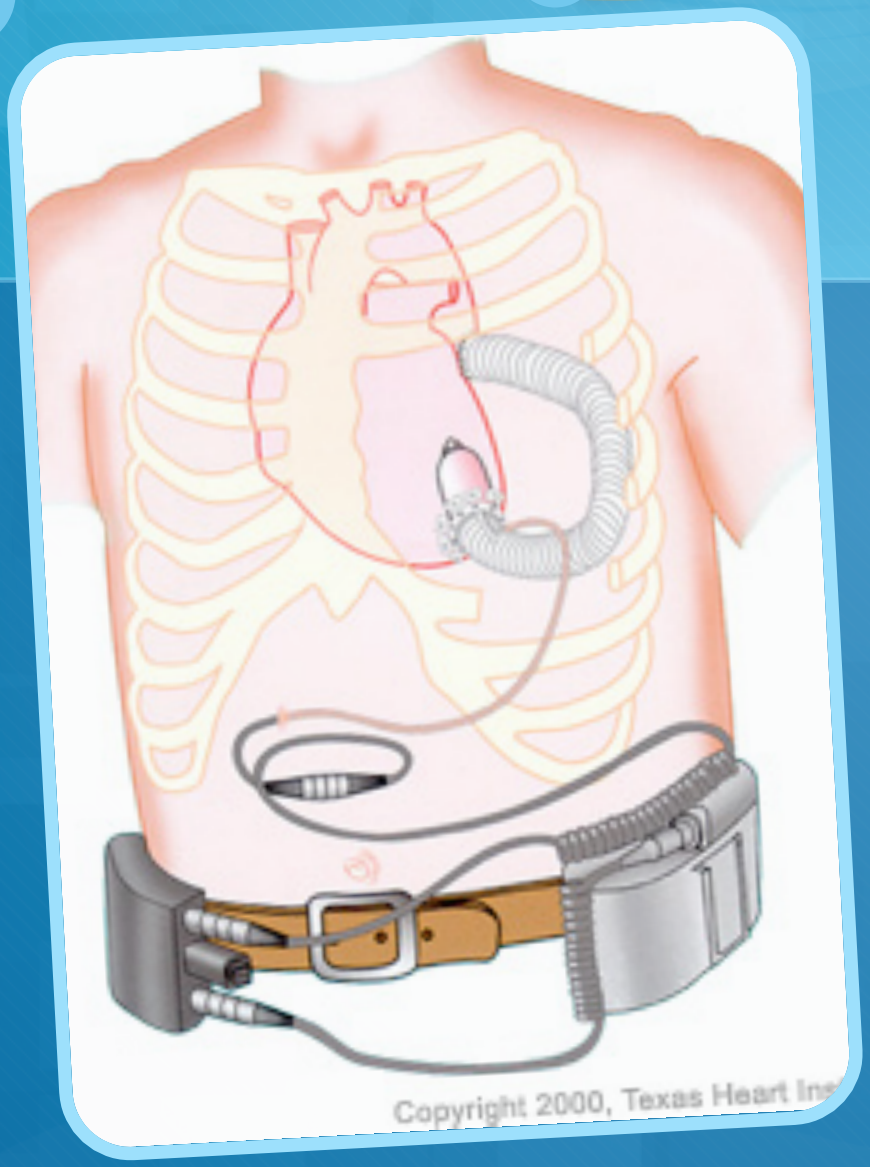


AbioCor

Jarvik 2000 LVAD

- made of titanium and steel
- valveless
- electrically powered pump
- Size of a C battery

Jarvik 2000

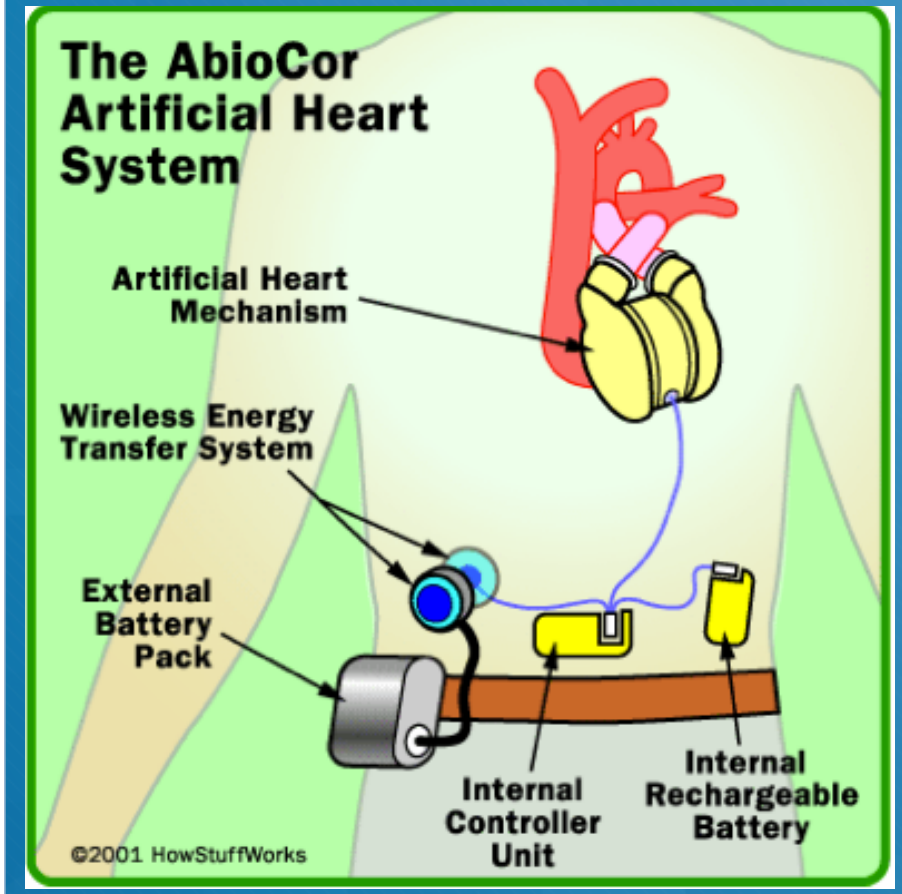


- Jarvik 2000 pump does not "beat."
- Instead, it uses a spinning rotor to propel blood from the left ventricle into the aorta.
- Speed:8000 – 12000 rpm
- Flow: 3-5 litres/min

AbioCor

- First total artificial heart transplant
- Fully mobile design
- Allows patients to carry-out their regular day activities in moderation
- Moving parts such as the valves and the hydraulic membranes are made from a specially engineered material called Angioflex.

AbioCor cosists of:



- Internal Control Motor
- Hydraulic pump
- Porting valve
- Artificial thoracic unit which contains two artificial ventricles
- Wireless energy-transfer system
- Electronic motoring devices
- Internal and external battery


AbioCor
Animation

AbioCor

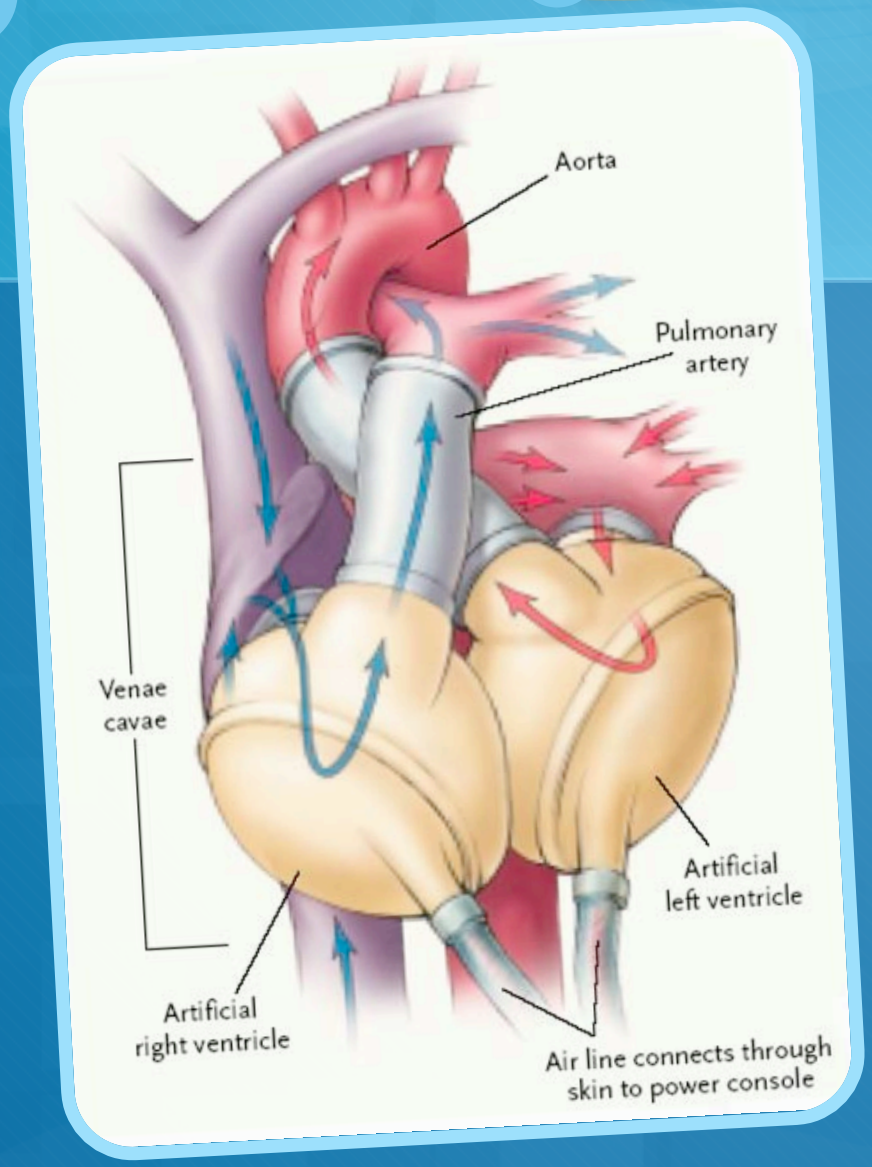
The FDA and ABIOMED officials have determined that patients to receive the AbioCor must meet the following criteria:

- Have end-stage heart failure.
- Have a life-expectancy of less than 30 days.
- Are not eligible for a natural heart transplant.
- Have no other viable treatment options.

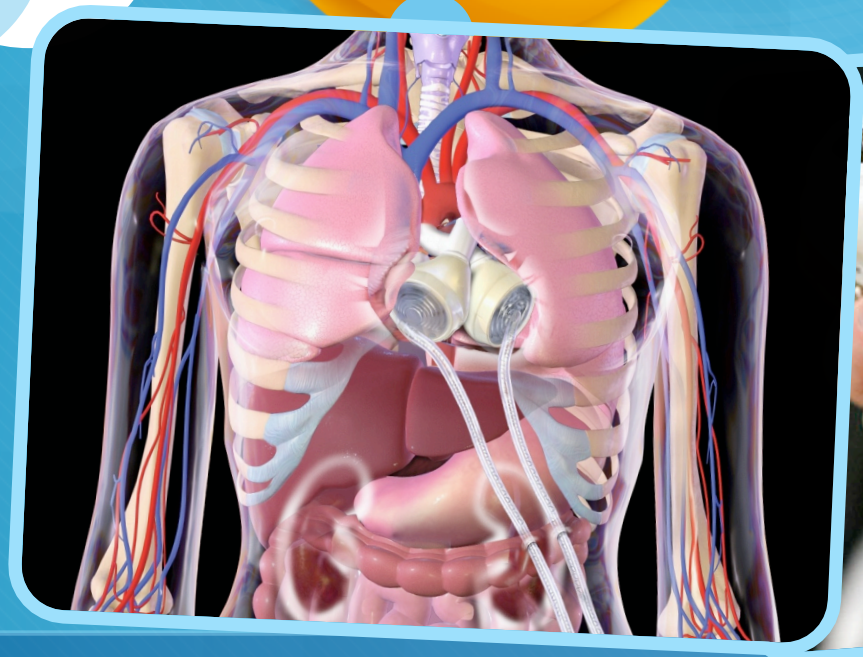
AbioCor

- The AbioCor unit costs about $70,000.
- The estimated cost for the artificial heart implantation is $160,000.
- The surgery itself takes about 7 hours to complete and can only be done in four hospitals in the U.S.

Syncardia CardioWest Total artificial Heart



- Is a TAH so ventricles are removed and artificial heart replaces the function
- Biventricular pneumatic pump
- Both sides are nearly identical
- Made of plastic and polyurethane
- There is an external console needed for the air and control



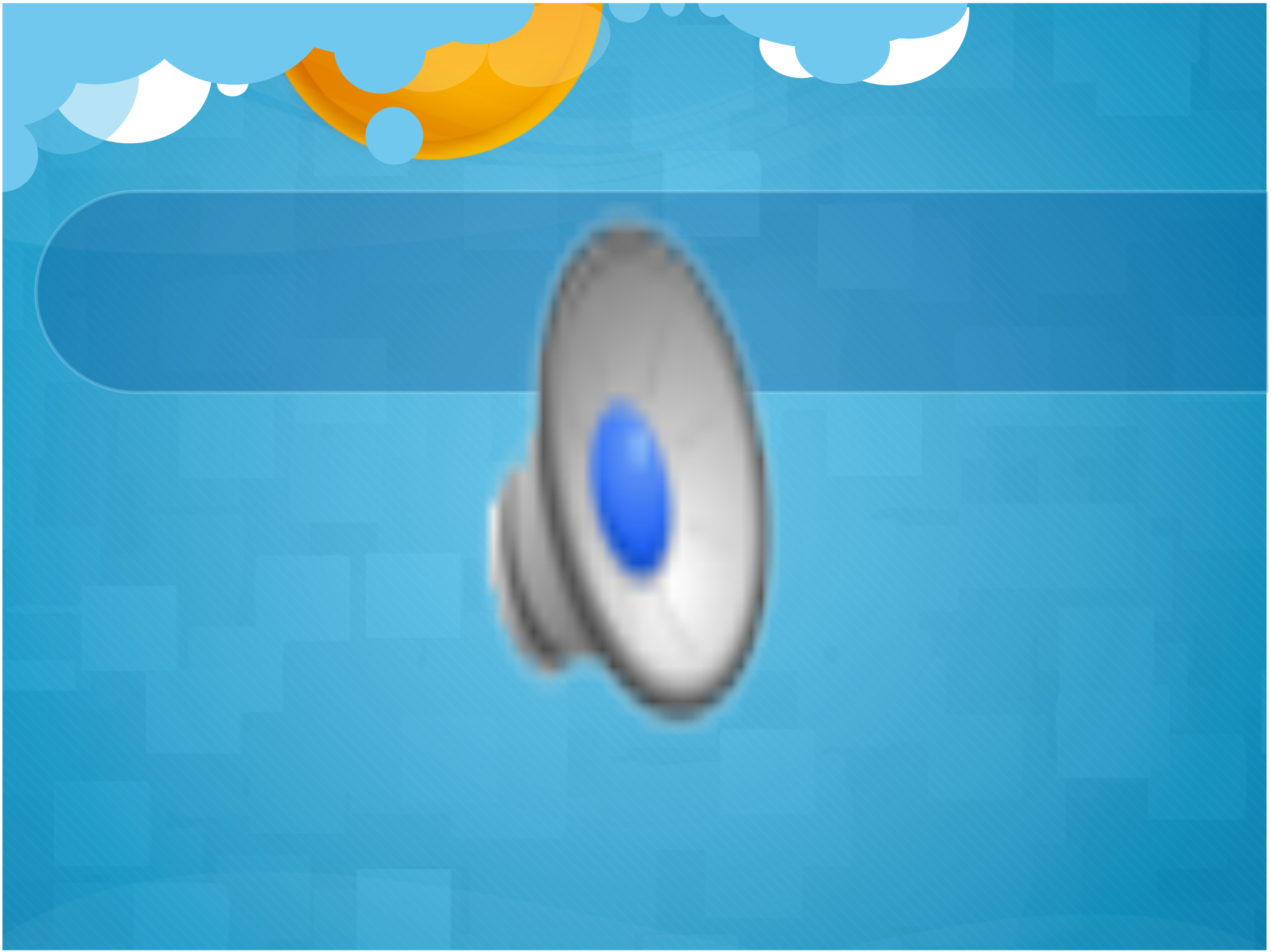
How it works

Uses the same concept as a diaphragm to function

Each side has its own diaphragm

Contracts and expands according to the external console and also controls the rate

External console pumps air in or out to cause pumping



Problems/Complications

- Bleeding
- Thrombosis
- Infection
  - sepsis is leading cause of death in long-term VAD support
- Device failure/malfunction (highly variable by device type)
- Hemolysis (the VAD destroys blood cells)

Future and Unsolved problems

The ideal heart needs to have the following characteristics:

- Small enough to be fully implantable
- No external power source
- No external wiring
- No blood thinners or other drugs need in conjunction (no blood clot build up in hearts)
- Can be used in day to day activities and return full quality of life
- Function is identical to the natural heart
- Long term usage
- Availability and cost

Conclusion

- Although a large number of artificial hearts are currently replacing damaged hearts they are still in their developmental stage.
- Scientist and engineers are still trying to invent a heart that is capable of replacing a normal heart for extended periods of time without “damaging the fluid or the cellular elements of the whole blood”.


QUESTIONS?

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