DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CBM352 Human Assist Devices

UNIT-I HEART LUNG MACHINE AND ARTIFICIAL HEART

Functioning and different types of Artificial Heart

A total artificial heart is a pump that is placed in the chest to replace damaged heart ventricles and valves. Ventricles are the chambers of the heart that pump blood to the lungs and other parts of the body.

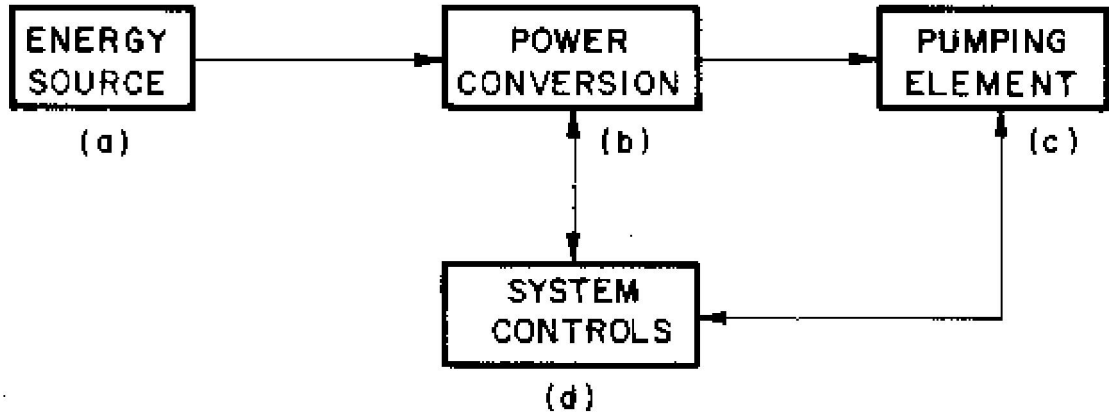


Fig. 1. Block diagram representation of an artificial heart.

An artificial heart, also known as a total artificial heart (TAH) or a mechanical circulatory support device, is designed to temporarily replace the function of a failing natural heart. The primary functions of an artificial heart include:

1. **Pumping Blood**: The main function of an artificial heart is to pump blood throughout the body, providing oxygen and nutrients to various organs and tissues. This helps maintain systemic circulation, preventing organ damage due to inadequate blood flow.

2. **Restoring Cardiac Output**: In cases of severe heart failure where the natural heart is unable to pump sufficient blood to meet the body's needs, an artificial heart can be implanted to restore cardiac output. This is crucial for maintaining organ function and preventing multi-organ failure.
3. **Bridge to Transplant**: Artificial hearts can serve as a bridge to heart transplantation for patients awaiting a suitable donor heart. The device provides circulatory support while the patient is on the transplant waiting list, helping them survive until a donor heart becomes available.
4. **Bridge to Recovery:** In some cases, where the heart failure is potentially reversible, an artificial heart can serve as a bridge to recovery. By temporarily assisting the heart's function, it allows the natural heart to rest and potentially regain strength, leading to the removal of the artificial heart once the patient's heart function improves.
5. **Monitoring**: Many modern artificial heart devices are equipped with monitoring capabilities that allow healthcare providers to assess the device's performance and the patient's overall cardiovascular status. Monitoring parameters may include blood flow, pressure, and other relevant data.
6. **Adjustability**: Some artificial hearts are designed to be adjustable, allowing healthcare providers to fine-tune the device's settings to match the patient's specific physiological needs. This adaptability is important for optimizing circulatory support.
7. **Integration with the Natural Heart**: Advanced artificial hearts are designed to work in conjunction with the patient's remaining natural heart. The synchronization between the artificial and natural components helps maintain a more physiological circulation.
8. **Patient Survival**: Ultimately, the primary function of an artificial heart is to sustain the patient's life when their natural heart is unable to do so adequately. This provides a viable therapeutic option for individuals with end-stage heart failure who are not responsive to other treatments.

It's important to note that artificial hearts are typically used as a temporary solution, either as a bridge to transplant or as a means of supporting the heart during a period of recovery. Continuous advancements in medical technology aim to improve the effectiveness and durability of artificial hearts while minimizing associated risks and complications.

Types of artificial Heart:

1. Jarvik 2000:

The Jarvik 2000 is a left ventricular assist device (LVAD), a type of mechanical circulatory support device. Please note that there may have been further developments or updates since then. The Jarvik 2000 is designed to assist the natural pumping function of the left ventricle of the heart.

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

Here are the key functions of the Jarvik 2000 LVAD:

Left Ventricular Support: The primary function of the Jarvik 2000 is to support or take over the pumping function of the left ventricle, which is responsible for pumping oxygenated blood to the rest of the body. By doing so, it helps maintain systemic circulation and ensures an adequate supply of oxygen and nutrients to organs and tissues.

Bridge to Transplant: The Jarvik 2000 is often used as a bridge to heart transplantation. Patients with end-stage heart failure who are awaiting a heart transplant may receive the Jarvik 2000 as a temporary measure to provide circulatory support until a suitable donor heart becomes available.

Destination Therapy: In some cases where heart transplantation is not an option, the Jarvik 2000 may be used as a long-term or "destination therapy." This means it serves as a permanent solution to support heart function and improve the quality of life for patients who are not eligible for heart transplantation.

Reduction of Heart Failure Symptoms: By assisting the heart's pumping function, the Jarvik 2000 can help alleviate the symptoms of heart failure, such as fatigue, shortness of breath, and fluid retention.

Continuous Flow Technology: The Jarvik 2000 is a continuous flow LVAD, meaning it utilizes continuous blood flow rather than the traditional pulsatile flow. Continuous flow devices are known for their smaller size, durability, and potentially lower rates of complications compared to pulsatile devices.

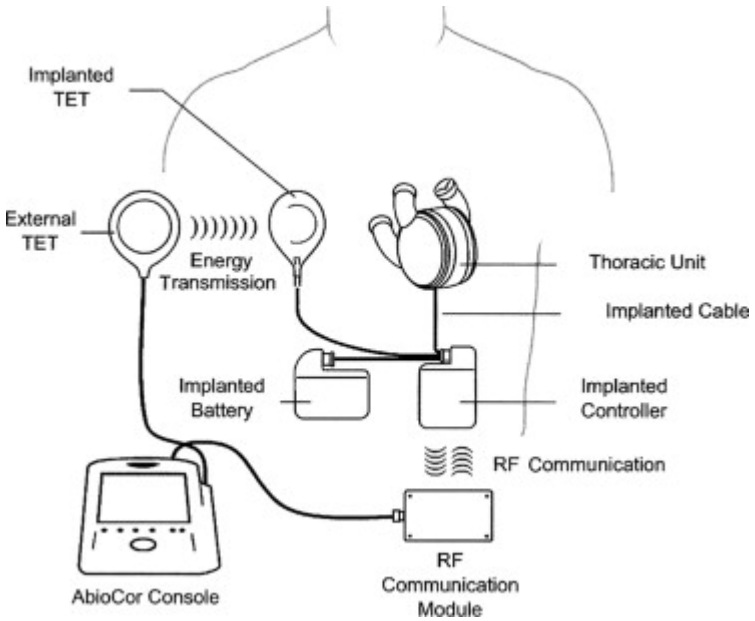
Compact Design: The compact design of the Jarvik 2000 allows for implantation in a less invasive manner, making it suitable for a broader range of patients. The smaller size may also contribute to improved patient comfort and reduced risk of complications.

Integration with Natural Heart: The Jarvik 2000 is designed to work in conjunction with the patient's remaining natural heart. It assists the left ventricle without replacing the entire heart, allowing for a more physiologically responsive circulatory support.

It's important to note that the use of LVADs like the Jarvik 2000 involves a comprehensive evaluation process, and decisions regarding implantation are made based on individual patient characteristics, medical history, and the specific circumstances of their heart failure.

2. AbioCor

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



The AbioCor Total Artificial Heart is an advanced medical device designed to replace the natural heart in patients with end-stage heart failure. Developed by Abiomed, the AbioCor is intended for use in patients who are not eligible for heart transplantation. As of my last knowledge update in January 2022, here are the key functions of the AbioCor Total Artificial Heart:

1. **Complete Heart Replacement**: The AbioCor is designed to completely replace the failing natural heart. It serves as both the left and right ventricles, pumping blood throughout the body and providing circulatory support.
2. **Pulsatile Flow**: Unlike some continuous flow left ventricular assist devices (LVADs), the AbioCor generates a pulsatile flow, mimicking the natural heartbeat. This pulsatile flow may contribute to a more physiological circulation.
3. **Internal Power Source**: The AbioCor has an internal power source that eliminates the need for external cables and connectors passing through the skin. This helps reduce the risk of infection and enhances patient mobility.
4. **Fully Implanted**: The device is fully implanted within the patient's chest, eliminating the need for an external console or pump. This design aims to enhance patient independence and quality of life.
5. **Wireless Energy Transmission**: The AbioCor utilizes wireless energy transmission to power the device. This technology allows for energy transfer across the skin, avoiding the need for percutaneous drivelines that can be a source of infection in other ventricular assist devices.
6. **Self-Contained Unit**: The AbioCor is a self-contained unit with an internal battery and control system. This autonomy reduces the reliance on external equipment and facilitates a more active lifestyle for the patient.
7. **Bridge to Transplant or Destination Therapy**: The AbioCor can serve as a bridge to heart transplantation for patients awaiting a donor heart. Additionally, in cases where heart transplantation is not an option, it can be used as a long-term or destination therapy to support the patient's circulatory needs.
8. **Advanced Monitoring**: The AbioCor includes advanced monitoring capabilities to assess the device's performance and the patient's overall cardiovascular status. This monitoring is crucial for optimizing device settings and ensuring proper circulatory support.

It's important to note that the AbioCor Total Artificial Heart is a complex and innovative medical technology. Decisions regarding its use are made on a case-by-case basis,

and patient selection is based on various factors, including medical history, overall health, and the severity of heart failure. Additionally, advancements in medical technology and clinical practices may have occurred since my last update.

3. Syncardia CardioWest Total artificial Heart

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

The Syncardia CardioWest Total Artificial Heart (TAH) is a medical device designed to replace the function of both the left and right ventricles of the natural heart. Here are the key functions of the Syncardia CardioWest Total Artificial Heart:

i. **Complete Heart Replacement**: The primary function of the Syncardia CardioWest TAH is to completely replace the failing natural heart. It is implanted when both the left and right ventricles are severely compromised, providing a solution for end-stage heart failure.

ii. **Biventricular Support**: The Syncardia TAH supports both the left and right sides of the heart. This is crucial for maintaining proper circulation, ensuring oxygenated blood is pumped to the rest of the body and allowing deoxygenated blood to flow to the lungs for oxygenation.

iii. **Pulsatile Flow**: The Syncardia TAH generates a pulsatile flow of blood, mimicking the natural heartbeat. Pulsatile flow is thought to contribute to more physiologic circulation and has potential benefits for end-organ function.

iv. **Bridge to Transplant**: The device can serve as a bridge to heart transplantation for patients who are awaiting a suitable donor heart. It helps sustain the patient's life and maintains circulatory function until a donor heart becomes available.

v. **External Pneumatic Driver**: The Syncardia TAH is powered by an external pneumatic driver or console, which is connected to the implanted device through tubes that pass through the patient's skin. The external driver regulates the pumping action of the artificial heart.

vi. **Adjustable Pump Speed**: The pump speed of the Syncardia TAH can be adjusted by healthcare providers to meet the individual needs of the patient.

This flexibility allows for optimization of circulatory support based on the patient's condition.

vii. **Portable Driver**: While connected to an external driver, the Syncardia TAH allows patients some mobility. The portable driver enables patients to move within certain limits, providing a degree of freedom and improving their quality of life.

viii. **Improved Organ Perfusion**: By maintaining circulation, the Syncardia TAH helps prevent organ failure and dysfunction that can result from inadequate blood flow. This is especially important in the context of end-stage heart failure where the natural heart's pumping ability is severely compromised.

It's important to note that the Syncardia CardioWest Total Artificial Heart is typically considered for use in patients with severe biventricular heart failure who are not eligible for other circulatory support devices or heart transplantation. The decision to implant the Syncardia TAH is made based on careful evaluation of the patient's medical condition and overall suitability for the device. Advances in medical technology and treatment options may have occurred since my last knowledge update.

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