Abstract:
Heart failure continues to be an ever-increasing problem day by day, affecting almost 23 million people worldwide and the risk is known to increase with age. Furthermore 5% of these patients are end-stage patients. Also many patients have severe biventricular failure or other conditions such as large recent infarctions, intractable arrhythmias, post infarction ventricular septal defects or complex native valve disease. This makes the implantation of left ventricular assist devices challenging. Also cardiovascular diseases (CVDs) are the number 1 cause of death globally. CVDs are a group of disorders of the heart and blood vessels and include coronary heart disease, cerebrovascular disease, rheumatic heart disease and other conditions. Four out of five CVD deaths are due to heart attacks and strokes, and one third of these deaths occur prematurely in people under 60 years of age. Also the global supply of donor hearts remains limited and not everyone who needs a heart transplant will receive a matching donor heart in time. The total artificial heart (TAH) is a bionic heart a new invention which proves most beneficial for serious heart patient. A total artificial heart (TAH) is a pump that is surgically installed to provide circulation and replace heart ventricles that are diseased or damaged. An artificial heart is a mechanical pump that is used to replace a damaged heart temporarily or permanently. Actually Total artificial heart (TAH) is a mechanical circulatory support system in which the patient’s native ventricles and valves are explanted and replaced by a pneumatically powered artificial heart. This artificial hearts have been used for temporary as well as permanent replacement of failing human hearts. Patients have lived on the TAH for more than 4.5 years. These patients would benefit from a replacement with a total artificial heart (TAH). TAH device is used now a days to save human life. Heart patients are increasing rapidly due to number of heart disease so the solution is bionic heart. Bionic heart has supported patients as young as 9 years old and as old as 80 years old. Now a day’s bionic heart proves ultimate solution for heart failure patients, heart disease patients who are below 60 years age.

Keywords: Heart failure, end-stage patients, mechanical circulatory support system, artificial heart, cardiovascular diseases (CVDs), Total Artificial Heart (TAH), Bionic heart, SynCardia.

Introduction
Heart is the engine of our body that pumps blood into various vessels. The organ works rigorously beating 100,000 times a day to keep our body freshly supplied with oxygen. Now a day’s heart disease, heart failures are become very serious & dangerous disease day by day. It is estimated that 1 in every 5 people will develop heart failure in their life time. But what will happen if our heart stops beating? Is this the end of our life? The answer is no.

Recognizing the need for an effective and immediately available alternative to a donor heart, surgeons, medical researchers and inventors began developing early versions of bionic heart during the first half of the 20th century. The development of TAHs was preceded by decades of research, experimentation, and collaboration conducted at various institutions around the world.

Much of the developmental work leading to the modern TAH was performed by Willem Kolff and his trainees. In 1957, Dr. Kolff and Tetsuzo Akutsu performed their first successful animal TAH implant in a dog supporting circulation for 90 minutes.

In 1967, the first human heart transplant was performed in South Africa by Christian Barnard. However, early experience with poor post-transplant survival would soon dampen enthusiasm. A similar experience would be repeated with the artificial heart.

In 1969, Denton Cooley and Domingo Liotta performed the first human TAH implant using the Liotta Heart (an experimental device designed by Dr. Liotta, a former trainee of Dr. Kolff). The patient was a 47-year-old man with ischemic cardiomyopathy who was unable to come off cardiopulmonary bypass following remodeling ventriculoplasty.

The TAH successfully provided hemodynamic support, but the patient quickly developed hemolysis and progressive renal failure. The patient was bridged to transplantation after 64 hours of support but unfortunately died 32 hours later from pseudomonal sepsis. The groundbreaking event was filled with controversy regarding improper consent and experimentation.

In 1981, Dr. Cooley performed the second human TAH implant (the Akutsu III, developed by Dr. Akutsu) in a 36-year-old man with post cardiomyopathy shock following coronary bypass surgery. The postoperative course was notable for renal failure and severe hypoxia secondary to left pulmonary venous obstruction and required veno-venous extracorporeal membrane oxygenation. The patient was bridged to transplantation after 55 h of support, but unfortunately died 1 week later from overwhelming sepsis.

In 1982, William DeVries performed the well-publicized permanent (now referred to as destination therapy) TAH implant of an artificial heart (the Jarvik 7, designed by Robert
Jarvik, another Kolff trainee) into Dr. Barney Clark (11). Dr. Clark was a 61-year-old man with non-ischemic cardiomyopathy, refractory ventricular arrhythmias and multiorgan dysfunction that precluded consideration for transplant. He was hemodynamically supported for 112 days.

By the late 1990s, patients with heart failure may be able to receive a fully implantable device to assist their weakened hearts. A small battery pack will be the only visible evidence of the technology, in contrast to the large console needed to power earlier models of these devices.

Five to ten years after assist devices are perfected, a fully implantable total artificial heart (TAH)—a device that replaces the natural heart instead of only assisting it—may be technologically possible. Since the first patient implant in 1969, medical teams across the globe have developed 13 different artificial heart designs that have been used in patients.

Many of these designs were initially intended to be permanent solutions. However, the majority have been used as temporary measures to keep a patient alive until a matching donor heart becomes available, known as a bridge to transplant.

Among those 13 artificial heart designs, these patients would benefit from a replacement with a total artificial heart (TAH). The SynCardia TAH (formerly Jarvik 7/Cardio West) device had been approved in Europe and the United States in 1999 and 2004. According to a 10-year clinical study by Copeland et al, SynCardia produced a 79% success rate as a bridge to transplantation and reasonable post cardiac transplant outcomes.

The mean duration of SynCardia support has been 15 to 90 days at different centers. In an early large series of more than 170 patients in the United States, most patients had been supported by the SynCardia device for less than 2 weeks. However, a recent report had been able to show that 72% of the patients who remained on the device more than 1 year could be successfully transplanted.

The TAH has supported patients as young as 9 years old and as old as 80. Patients have lived on the TAH for more than 4.5 years. Stable TAH patients are able to leave the hospital and enjoy active lives at home while they wait for a donor heart.

Total Artificial Heart (TAH) is the only one to receive commercial approval in the U.S. (FDA), Canada (Health Canada) and Europe (CE mark). In clinical use for more than 35 years. The major breakthrough was a bionic heart in 2001, when a Brisbane engineer Dr. Daniel Timms conducted a clinical trial on sheep, that contained a spinning disc with small blades on each side that pump blood around the body and lungs, without a traditional pulse.

They developed a bionic heart which could last at least 10 years and could help bridge the gap between patients requiring heart transplants and the number of donor hearts available. Now a days The TAH is available at more than 140 hospitals in over 20 countries. Clinical use for more than 35 years, the SynCardia TAH has been implanted more than 1,800 times, accounting for more than 600 patient-years of support.

### Table 1: HISTORY CHART OF BIONIC HEART.

<table>
<thead>
<tr>
<th>Year</th>
<th>Scientist</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1953</td>
<td>Dr. John Gibbon</td>
<td>A Heart-Lung Machine</td>
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<tr>
<td>1964</td>
<td>The National Heart, Lung and Blood Institute</td>
<td>Set a goal to design TAH by 1970</td>
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<tr>
<td>1966</td>
<td>Dr. Michael DeBakey</td>
<td>Implantation of a partial artificial heart</td>
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<tr>
<td>1967</td>
<td>Dr. Christiaan Bernard</td>
<td>Human Heart Transplant</td>
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<tr>
<td>1969</td>
<td>Dr. Denton Cooley</td>
<td>Total artificial heart</td>
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<tr>
<td>1982-85</td>
<td>Dr. William DeVries</td>
<td>Jarvik total artificial heart</td>
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<tr>
<td>1994</td>
<td>Food and drug Administration</td>
<td>Approval the Left V ventricular Assist Device</td>
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<tr>
<td>2000</td>
<td>Texas Heart Institute</td>
<td>Jarvik 2000</td>
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<tr>
<td>2001</td>
<td>Abiomed Inc.</td>
<td>AbioCor</td>
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A) Operating principles

1. The SynCardia TAH is made of a special plastic called segmented polyurethane solution (SPUS). Made in SynCardia’s laboratory in Tucson, Arizona, segmented polyurethane solution (SPUS) has a high degree of fatigue resistance, strength and biocompatibility, which makes it an ideal material for manufacturing multiple components of the TAH. The TAH is manufactured in two different sizes of 70cc and 50cc to fit for more patients. The 70cc TAH fits a majority of men and some women, and it can generate blood flow of up to 9.5 liters per minute, depending on the patient’s needs. The smaller 50cc TAH is designed to fit a majority of women and some adolescents, and it can generate blood flow of up to 7.5 liters per minute, depending on the patient’s needs. In comparison, the average human heart at rest pumps an average of 5 liters of blood per minute.

2. The TAH is pulsatile and has two ventricles and four valves just like the human heart. A heart transplant, the SynCardia TAH replaces both lower chambers of the heart (the left and right ventricles) and the four heart valves to restore blood flow to the body and eliminate the symptoms and source of heart failure. The SynCardia TAH is pumped and monitored by an external machine called a driver, which produces pulses of air and vacuum that help pump blood in and out of the ventricles. The TAH is made of a highly durable, biocompatible material. Unlike a donor heart, the TAH is readily available when needed (no wait list), not restricted by blood type or antibody level (no matching required) and is biocompatible with the body (no anti-rejection medications needed).

3. Left ventricular assist devices (LVADs) and artificial hearts are improving. These devices can prolong a patient’s life while on a heart transplant list. More exciting, mechanical assistance may provide an opportunity for a damaged heart to recover some function the primary material used to manufacture the SynCardia temporary Total Artificial Heart (TAH) — is strong, durable and uniquely suited for use inside the human body. The TAH has supported patients as young as 9 years old and as old as 80 years old.

Material uses: - An artificial heart is made out of metal, plastic, ceramic, and animal parts. A titanium-aluminum-vanadium alloy is used for the pump and other metal parts.

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because it is biocompatible and has suitable structural properties. The titanium parts are cast at a specialized titanium processor.


Figure 1: BLOOD FLOW THROUGH HEART.

Figure 2: BIONIC HEART IMPLANTED IN PATIENT BODY.

B) Components required for artificial heart


2) Control and driving system- Fixed or variable (manually or automatically). Control of pulse rate, stroke volume, systole-diastole ratio, and pressure curves.

3) Energy conversion -Electromagnetic motor. Air and water driven by motorized bellows or piston, piezoelectric bimorph discs.


1. Advantages

1) Bionic heart can permanently replace the heart in case where a heart transplant is impossible.

2) TAH is readily available when needed (no wait list).

3) Not restricted by blood type or antibody level.

4) No matching required and is biocompatible with the body.

5) No anti-rejection medications needed and TAH can be implanted immediately in the patient body to save human heart without waiting for donor heart.

6) The main advantage with artificial hearts is that they are not rejected by the body's immune system. This is because they are made from metals or plastics, so the body doesn't recognize them as 'foreign' and attack in the same way it does with living tissue unlike a donor heart.
7) Bionic heart has supported patients as young as 9 years old and as old as 80 years old.

8) Artificial heart transplant can give a patient an extra month or up to 5 years extra life.

9) There are not enough real hearts donated so artificial hearts could replace them.

2. Disadvantages

1) Surgery to fit an artificial heart can lead to bleeding and infection.

2) Artificial hearts don't work as healthy as natural ones—parts could wear out or the electrical motor could fail.

3) Blood flow doesn't flow through artificial hearts as smoothly, which can cause blood clots and lead to strokes.

4) The patient has to take drugs to thin their blood and make sure this doesn't happen, which can cause problems with bleeding if they are hurt in an accident.

5) Just one artificial heart is currently approved for human use in the U.S., but its manufacturer describes it as a temporary device. Artificial hearts have mostly been viewed as short-term fixes to help ailing patients while they wait for a human heart transplant.

6) It is designed to last up to five years and be used in patients who aren't eligible for a human transplant, or those waiting for one. Larger than a normal human heart, it is not suitable for some women and children.

7) The heart battery needs recharging twice a day, otherwise the heart will stop.

8) Artificial hearts cost between £50,000 and £100,000 (pounds) each to make it and need TAH need to look after.

Conclusion

In day to day life large peoples are dying by heart diseases. Even though angioplasty, angiography operations there is no chance of life. How long heart work cannot say. Now a days child, teenagers, people below 50 years old are subjected to heart diseases, for such all age people TAH implantation is an effective therapeutic option for the treatment of patients.

TAH is very much helpful with end-stage biventricular heart failure patients. The duration of implantation varies depending on a particular patient's medical condition and the eventual availability of a human heart for orthotopic transplantation. TAH recipients often undergo imaging with conventional radiography, CT or both for the assessment of device-related issues, many of which are life-threatening and require emergency management. As the clinical use of the TAH increases and becomes more common place, it is imperative that radiologists interpreting imaging studies recognize both the expected and the unexpected imaging findings that affect patient care.

The BiVA COR is a total artificial heart that is designed to take over the complete function of a patient’s natural heart. Another way to imitate natural heart is by the help of tissue engineering, but according to scientists we are way far behind to achieve it. So, it's a continuous research subject area of development. Research of bionic heart must carry out till the donor heart need ceased to save heart patient life & to extend the life of patient. So now a days we need total artificial heart which must match with all body type of human including woman, childrens, very old people as the problem arises with infections, not matching with body, not support body, blood clotting problems must remove.

The TAH must smooth, easily functioning, human can breathe easily, and human can work normally like natural heart. Also the cost of TAH must affordable for every people. According to the recent studies by the U.S. Department of Health & Human Services, about 4,000 people wait for a donor heart transplant on any given day, and among European Union countries, 3,400 patients were on waiting lists for a donor heart in 2012. A total artificial heart that can mimic natural heart will bring boon to their lives. Invention may take place continuously for removing drawbacks of bionic heart then human can live with bionic heart life long without human heart. This will become real invention of bionic heart.

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