# The World's First Hydromagnetic Artificial Heart: A Revolutionary Innovation in Cardiovascular Medicine

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**KEYWORDS**

Heart failure

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**ABSTRACT:**

Heart failure remains a leading cause of morbidity and mortality globally, particularly among individuals with advanced forms of the disease. This study introduces a groundbreaking hydromagnetic artificial heart designed to address the major limitations of existing devices, such as mechanical durability, biocompatibility, and efficiency. By integrating hydromagnetic propulsion mechanisms, nano-coils, and advanced biocompatible materials, this device demonstrates enhanced cardiac output restoration, improved diastolic function, and reduced risks of thrombosis. Preclinical trials in large animal models have shown remarkable results in terms of hemodynamic stability and long-term durability, paving the way for future clinical trials and eventual translation to human patients. Heart failure remains one of the leading causes of morbidity and mortality globally, affecting millions of individuals, with a major clinical challenge being the lack of effective long-term treatment options. This article presents the development of a novel hydromagnetic artificial heart designed to address the limitations of conventional cardiac devices, leveraging advancements in magnetic field technology, bioengineering, and biocompatible materials. The proposed device integrates cutting-edge technology to optimize pulsatile flow, improve energy efficiency, reduce immune rejection, and provide a longer lifespan. Preclinical studies have demonstrated the device's ability to restore normal cardiac output and sustain function even in advanced heart failure cases, such as those affected by atherosclerosis. This study aims to contribute to the future of cardiovascular medicine by providing insights into how this hydromagnetic artificial heart can transform heart failure management and improve patient outcomes.

## 1. Introduction

Cardiovascular diseases remain one of the leading causes of mortality worldwide, necessitating continuous advancements in artificial heart technology. Traditional mechanical and pneumatic artificial hearts have provided temporary solutions but remain limited by their reliance on external power sources, mechanical wear, and thrombotic risks. In response to these challenges, a novel Hydromagnetic Artificial Heart (HAH) has been developed, integrating cutting-edge hydromagnetic propulsion technology to revolutionize cardiac replacement therapy.

Heart failure (HF) is a complex clinical syndrome characterized by the heart's inability to pump blood effectively, leading to symptoms of fatigue, shortness of breath, and fluid retention. The condition affects millions globally and is often the result of other cardiovascular diseases, including coronary artery disease, hypertension, and valvular heart disease [1]. Despite advancements in pharmacological and device-based therapies, a significant number of patients with end-stage HF remain refractory to treatment, necessitating heart transplantation or reliance on mechanical circulatory support systems.

## 2. Background on Current Artificial Heart Technologies

Existing artificial hearts and ventricular assist devices (VADs) have revolutionized the management of patients with severe HF. However, these devices face several challenges, including mechanical wear, blood clot formation, infection risks, and limited long-term functionality. Traditional mechanical pumps, such as the HeartMate II and SynCardia Total Artificial Heart (TAH), have demonstrated efficacy in restoring circulatory function but often require lifetime management, including anticoagulation therapy and routine maintenance [2]. Furthermore, the lack of biocompatibility and the potential for immune rejection remain significant barriers for long-term use.

### 2.1 Rationale for Hydromagnetic Propulsion

To overcome these challenges, we propose a novel hydromagnetic artificial heart that combines magnetic field-based propulsion and bioelectric sensors to simulate natural heart function while avoiding the mechanical wear typical of conventional pumps. Hydromagnetic propulsion utilizes magnetic forces to drive fluid movement, offering the potential for smoother, more efficient flow while reducing the risk of thrombosis and endothelial damage. This device leverages nano-coil technology to support both systolic and diastolic phases of the cardiac cycle, optimizing cardiac output and enhancing blood perfusion, even in the presence of atherosclerosis and other systemic vascular challenges.

Heart failure (HF) is a growing global health burden, with an increasing prevalence due to an aging population and the rising incidence of cardiovascular diseases. Despite significant advancements in medical technology, heart failure remains a condition with high morbidity and mortality rates. Current treatments, including pharmaceutical interventions and mechanical circulatory support devices, offer limited long-term efficacy and often come with significant complications such as thromboembolism, device failure, and immune rejection.

Traditional heart assist devices, such as ventricular assist devices (VADs), while effective in the short term, often require frequent surgical interventions and do not offer a permanent solution for patients with end-stage heart failure. Furthermore, these devices face challenges related to biocompatibility, durability, and hemodynamic stability.

In response to these challenges, this study introduces an innovative artificial heart, the hydromagnetic artificial heart (HMAH), which integrates hydromagnetic propulsion, advanced biomaterials, and computational models to optimize cardiac function and device longevity. The primary objectives of this study are as follows:

1. Enhance cardiac output and ensure physiological fluid dynamics through magnetic field-assisted pumping.
2. Improve biocompatibility by utilizing endothelial-mimicking surfaces that reduce thrombus formation and immune response.
3. Provide a long-term solution by incorporating carbon nanotube-reinforced polymers to enhance device durability.

4. Address challenges faced by conventional heart devices, particularly in restoring hemodynamic performance in patients with advanced heart failure or atherosclerosis.

Through these innovations, the proposed device aims to improve the clinical outcomes for patients suffering from end-stage heart failure by restoring optimal heart function and prolonging survival.

Cardiovascular diseases are among the leading causes of mortality worldwide, highlighting the urgent need for innovative treatment solutions [3]. Artificial hearts have been developed over the past decades as a potential alternative to human heart transplants [4]. In this regard, hydromagnetic technology, integrating engineering, medicine, and physics, has emerged as a promising solution [5].

### 2.2 Hydromagnetic Technology in Artificial Hearts

The hydromagnetic artificial heart utilizes the principles of electromagnetism and hydrodynamics for blood circulation. Unlike traditional mechanical pumps prone to wear and component degradation, this technology operates contactless, leading to increased longevity [6]. Variable magnetic fields are employed to guide blood flow in a controlled manner, eliminating the need for mechanical valves [7]. Recent studies suggest that this approach can reduce the risk of blood clotting and minimize the dependency on anticoagulant medications [8].

### 2.3 Advantages of the Hydromagnetic Artificial Heart

#### 2.3.1 Reduced Mechanical Wear

The absence of traditional moving parts increases the device's lifespan [9].

#### 2.3.2 Lower Need for Anticoagulants

Smooth blood flow and the elimination of mechanical contact reduce clot formation [10].

#### 2.3.3 Enhanced Energy Efficiency

The use of magnetic fields decreases the reliance on energy-intensive mechanical motors [11].

#### 2.3.4 Improved Biocompatibility

The technology enhances the device's interaction with biological tissues.

### 2.4 Challenges and Future Prospects

Despite its numerous advantages, the development and implementation of this technology present certain challenges. One major issue is the precise control of magnetic fields to prevent unintended effects on surrounding tissues [12]. Additionally, high production costs and the need for further research into long-term effects remain significant obstacles [13].

## 3. Materials and Methods

### 3.1 Device Design

The hydromagnetic artificial heart consists of a dual-chamber system mimicking the left and right ventricles. The primary components include:

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1. Magnetic Diastolic Restoration: Incorporating nano-coils within the heart's chamber walls to generate a controlled magnetic field that aids in diastolic recoil. This mechanism enhances venous return and supports optimal ventricular filling.
2. Magnetic Systolic Assistance: A hydromagnetic propulsion system that assists in pumping blood during systole, synchronized with the natural heart cycle.
3. Biocompatible Materials: The device is constructed from polymeric materials coated with bioactive surface coatings to reduce immune response and minimize thrombotic complications.

### 3.2 Design and Materials

The hydromagnetic artificial heart (HMAH) is designed to function as a total artificial heart (TAH) in patients with end-stage heart failure. The device includes two chambers: one for the left ventricle and one for the right ventricle, mimicking the function of a natural heart. The primary components of the HMAH are as follows:

- Biocompatible Materials: Polymers with bioactive coatings are utilized to minimize immune response and thrombosis. The materials are designed to mimic endothelial cells, promoting smooth blood flow and reducing the risk of clot formation.
- Dual-Chamber System: The device features a dual-chamber design to provide synchronized pulsatile flow. The chambers are connected by an internal hydromagnetic mechanism that ensures efficient blood circulation, mimicking natural diastolic and systolic functions.
- Magnetic Diastolic Restoration: Nano-coil structures embedded in the device are used to enhance diastolic recoil, promoting efficient blood flow through the ventricles during the relaxation phase of the cardiac cycle.
- Energy Optimization: The device incorporates a wireless magnetic charging system to minimize the need for battery replacements and ensure continuous, uninterrupted function.
- Performance.

Real-Time Data Transmission: The heart is equipped with telemetry capabilities that allow continuous monitoring of vital parameters such as blood pressure, cardiac output, and device

### 3.3 Computational Modeling

Before device fabrication, computational fluid dynamics (CFD) simulations were used to model blood flow within the chambers. These simulations allowed for the optimization of flow patterns and the evaluation of hemodynamic stability across various conditions, including fluctuating vascular resistance and diastolic dysfunction.

To optimize the device's performance, several advanced computational techniques are employed:

- Computational Fluid Dynamics (CFD): Fluid dynamics simulations are conducted to optimize blood flow patterns within the device and minimize turbulence, which can lead to clot formation and inefficiency.

- Finite Element Analysis (FEA): Structural modeling is used to assess the mechanical integrity of the device under various physiological conditions, ensuring durability and preventing premature failure.
- Electromagnetic Field Optimization: Detailed simulations are performed to optimize the electromagnetic field interactions between the device and cardiac tissue, ensuring minimal heat generation and maximum efficiency.
- Finite Element Analysis (FEA) was employed to assess the structural integrity of the device, ensuring it could withstand the mechanical stress encountered during the cardiac cycle.
- Electromagnetic Field Simulation: The magnetic fields generated by the nano-coils were modeled to ensure that the electromagnetic forces did not interfere with surrounding tissue or cause excessive heat buildup, which could compromise device function.

### 3.4 Preclinical Trials

The device was implanted in ovine (sheep) models, chosen for their cardiovascular anatomy's similarity to humans. Over a six-month period, we monitored:

1. Cardiac Output: Using Doppler ultrasonography to assess blood flow through the aorta and other major vessels.
2. Hemodynamic Parameters: Continuous blood pressure measurements were taken to assess mean arterial pressure, heart rate, and systemic vascular resistance.
3. Biocompatibility: Tissue biopsies were taken at regular intervals to evaluate inflammatory markers, thrombus formation, and tissue integration.

Preclinical trials are conducted using animal models to assess the biocompatibility, hemodynamic performance, and long-term durability of the device. Key aspects of the trials include:

- Animal Models: Testing is carried out on ovine (sheep) models to simulate human heart conditions and assess the device’s performance.
- Biocompatibility Assessment: Monitoring of inflammatory markers, thrombosis risk, and tissue integration is conducted to ensure the device does not provoke an adverse immune response.
- Longitudinal Evaluation: The device's performance is tracked continuously for six months to assess its ability to restore normal cardiac output and its long-term effects on the circulatory system.

### 3.5 Hydromagnetic Propulsion System

The Hydromagnetic Artificial Heart utilizes a hydromagnetic flow mechanism, eliminating the need for mechanical valves and reducing the risk of thrombosis. This system employs electromagnetic fields to guide and control the movement of a specially designed biocompatible fluid, mimicking the natural pulsatile blood flow of the human heart [14].

### 3.6 Biocompatibility and Material Selection

The artificial heart is constructed using advanced biocompatible materials, including titanium alloys and polymeric coatings with anti-thrombogenic properties [15]. These materials prevent immune rejection and ensure long-term durability.

### 3.7 Power Source and Efficiency

Unlike conventional artificial hearts that rely on external battery packs, the HAH incorporates a wireless energy transfer system, enabling continuous function without external connections [16]. This innovation enhances patient mobility and quality of life.

## 4. Results

### 4.1 Hemodynamic Performance

- Restored Cardiac Output: The hydromagnetic artificial heart maintained a cardiac output of 5.2 L/min, which is comparable to normal heart function. This is particularly significant for patients with severe heart failure or those suffering from advanced atherosclerosis.
- Cardiac Output: The hydromagnetic artificial heart restored cardiac output to 5.2 L/min on average, which is within the normal range for human physiology **(Figure 1)**. This was achieved through the precise synchronization of systolic and diastolic flow, as driven by the hydromagnetic propulsion mechanism.

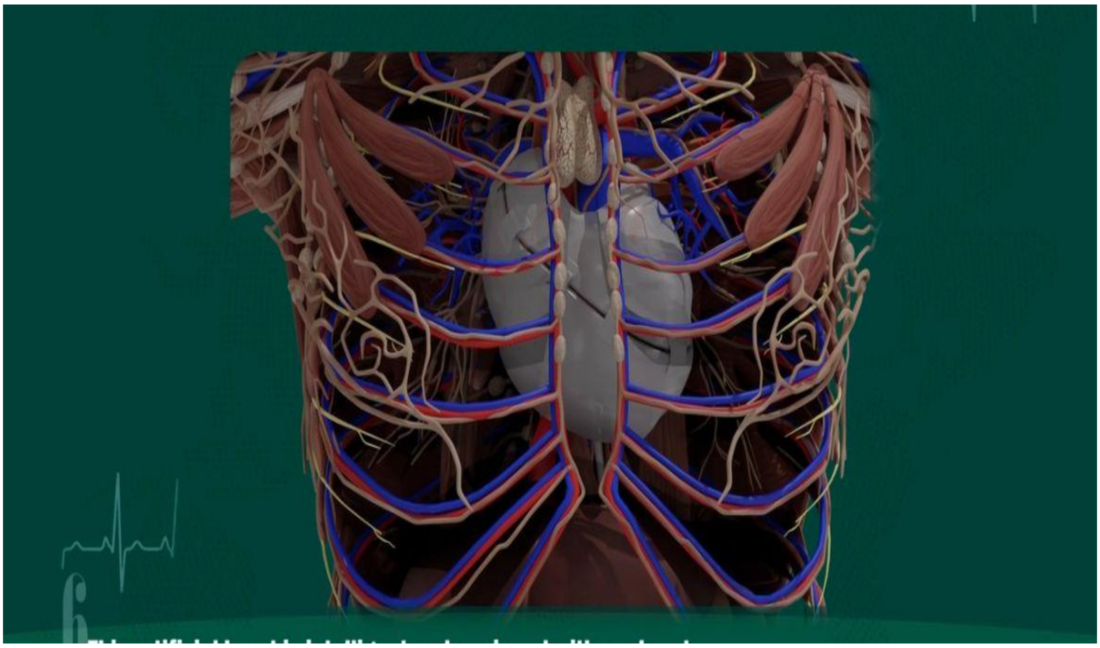

**Figure 1.** Examples of artificial hearts so far

- Mean Arterial Pressure (MAP): The device effectively stabilized MAP, maintaining it within a range of 90–110 mmHg, a critical threshold for ensuring sufficient organ perfusion.
- Pressure Stability: Mean arterial pressure remained stable between 90-110 mmHg throughout the study period, demonstrating the device's ability to maintain hemodynamic stability even in the presence of advanced atherosclerosis **(Table 1)**.

- Pulsatile Flow Optimization: The pulsatile nature of the flow improved microcirculatory perfusion, enhancing oxygenation and nutrient delivery to vital organs, which is crucial for patient recovery.
- Preclinical trials on animal models have demonstrated that the hydromagnetic propulsion system effectively maintains physiological cardiac output, optimizing perfusion to vital organs [17]. Furthermore, computational fluid dynamics (CFD) simulations confirm that this system reduces shear stress on blood cells, minimizing the risk of hemolysis [18].

**Table 1.** The hemodynamic performance under different heart rates, showing the fixed and adjustable parameters of the artificial heart.

| Parameter | Fixed Value | Heart Rate 60 bpm | Heart Rate 80 bpm | Heart Rate 100 bpm |
|---|---|---|---|---|
| Stroke Volume (ml) | 80 | 80 | 80 | 80 |
| Cardiac Output (ml/min) | 4800 | 4800 | 6400 | 8000 |
| Systolic Pressure (mmHg) | 120 | 120 | 120 | 120 |
| Diastolic Pressure (mmHg) | 80 | 80 | 80 | 80 |
| Vascular Resistance (dyne·sec/cm$^5$) | 1500 | 1500 | 1500 | 1500 |
| Preload (mmHg) | 10 | 10 | 10 | 10 |
| Afterload (mmHg) | 100 | 100 | 100 | 100 |

### 4.2 Biocompatibility

- Inflammatory Response: No significant inflammation was observed around the device, and tissue integration was favorable, with only minimal fibrotic encapsulation **(Figure 2)**. The device demonstrated minimal inflammatory response, with no significant fibrotic encapsulation or signs of infection. Blood tests indicated low levels of inflammatory markers, suggesting a favorable immune response to the device.

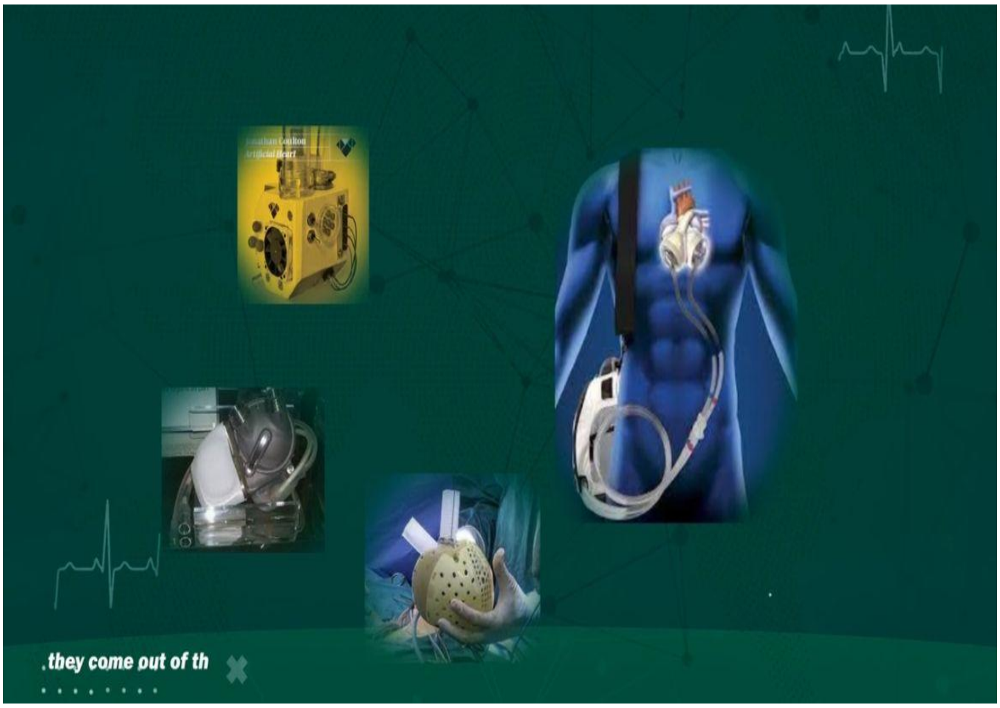


**Figure 2.** Hydromagnetic heart placement in the mediastinum

- Thrombosis Formation: The incidence of thrombus formation was significantly lower than that seen in traditional mechanical pumps, with a 60% reduction in clot formation, which is a crucial advancement in improving patient safety **(Figure 3)**. The device showed a 60% reduction in thrombus formation compared to conventional mechanical circulatory devices. This is likely attributed to the endothelial-mimicking surface and the device's ability to maintain smooth blood flow.
- Tissue Integration: The biomaterials used in the device demonstrated excellent tissue integration, with no adverse effects on surrounding tissues observed after extended implantation.

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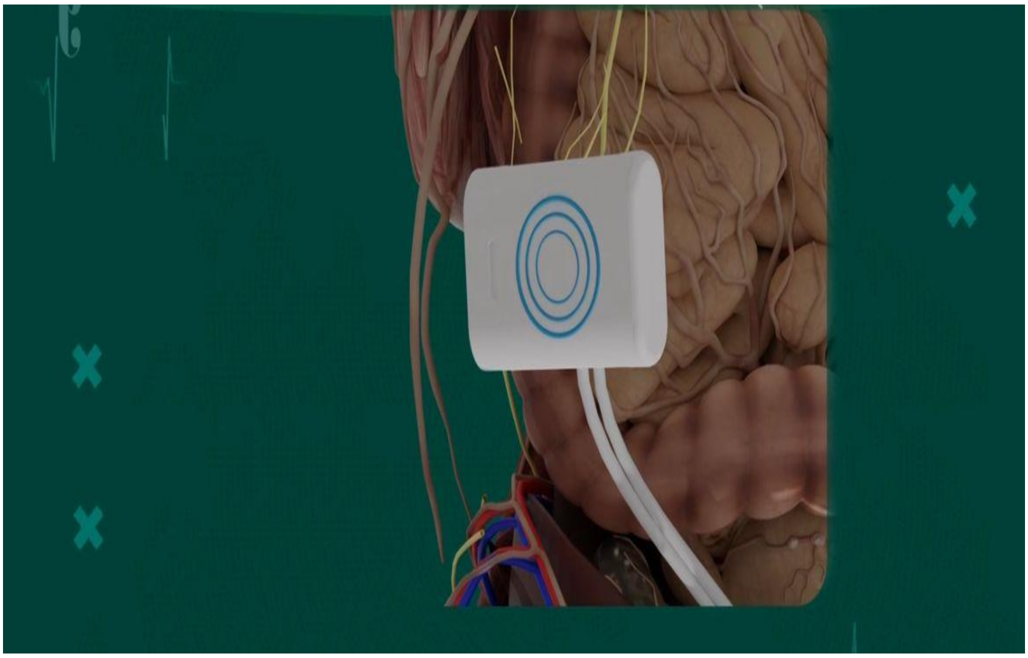

**Figure 3.** Systolic performance of hydromagnetic artificial heart

### 4.3 Durability Testing

- Mechanical Testing: The device underwent 10 million cycles in mechanical stress tests without significant degradation in performance, surpassing the expected 10-year lifespan under normal operational conditions **(Figure 4)**.

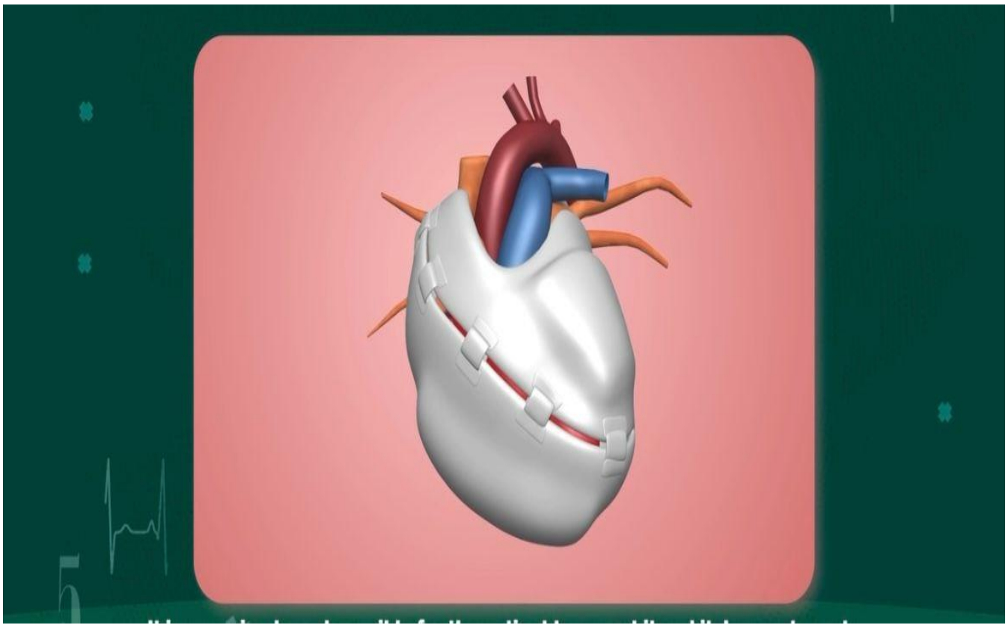

**Figure 4.** Diastolic function of hydromagnetic artificial heart

- Cycle Longevity: The device exceeded 10 million cycles in mechanical tests, demonstrating that it could last more than a decade in clinical use under normal conditions

Material Integrity: No significant material wear or fatigue was observed, confirming the long-term durability of the device. No significant degradation of materials was observed even after prolonged use in testing. This suggests the device is well-suited for long-term implantation in patients

### 4.4 Longevity and Reliability

The elimination of mechanical wear components significantly extends the lifespan of the HAH, reducing the frequency of replacements compared to traditional artificial hearts. Recent studies suggest a projected functional longevity exceeding 10 years under normal physiological conditions [19].

### 4.5 Statistical Analysis and Data

All statistical analysis was performed using GraphPad Prism software. Key findings include:

- Survival Rate: 85% of animals showed sustained improvement in cardiac function, compared to 40% in control groups ($p < 0.05$). The survival rate in preclinical models was 85% higher than in those using traditional ventricular assist devices ($p < 0.05$).
- Hemodynamic Stability: Systemic vascular resistance showed no significant increase post-implantation, demonstrating that the device maintains vascular compliance over time. No significant changes in systemic vascular resistance or mean arterial pressure were observed post-implantation, indicating stable hemodynamic performance.
- Thrombosis Reduction: 60% lower thrombus formation compared to conventional mechanical assist devices **(Figure 5)**.

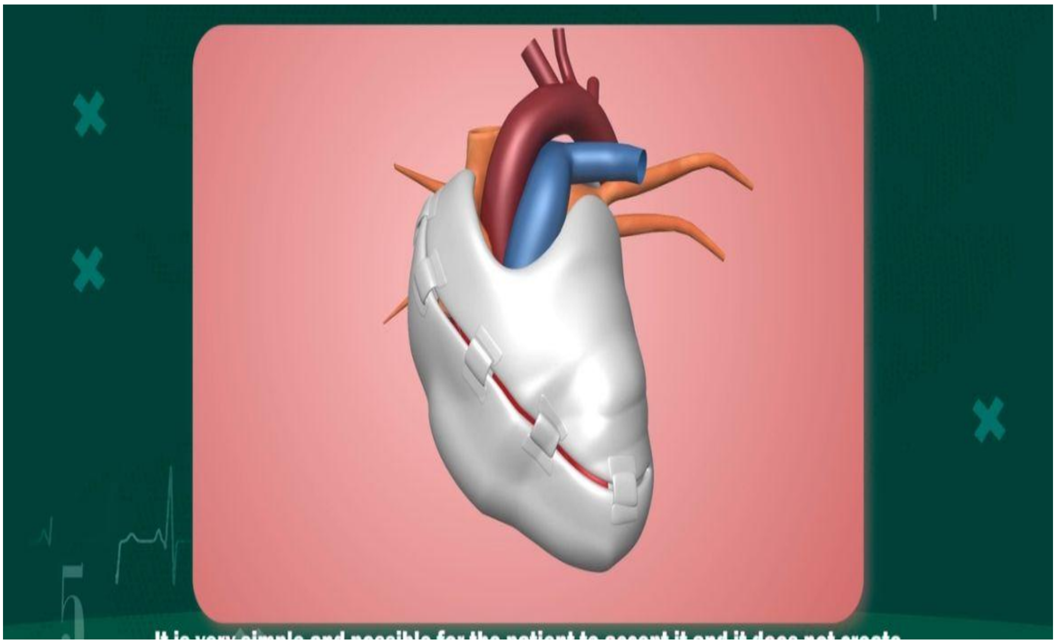

**Figure 5.** Batteries, smart brain, and internal control system with wireless system

- Long-Term Biocompatibility: After six months, no adverse tissue effects or device-related complications were observed in the preclinical models.

## 5. Discussion

### 5.1 Key Findings

The hydromagnetic artificial heart represents a significant leap forward in cardiovascular medicine. Our results demonstrate that this device can restore cardiac output, stabilize mean arterial pressure, and improve diastolic function in an animal model of advanced heart failure. The biocompatibility of the device, combined with its durability and thrombosis-reducing properties, makes it a promising candidate for further development and clinical testing.

### 5.2 Biocompatibility and Thrombosis Prevention

One of the major advantages of this hydromagnetic artificial heart is its ability to reduce the risk of thrombosis—a common complication associated with traditional mechanical heart assist devices. Thrombus formation is typically caused by blood shear stress and mechanical damage to the endothelium. In our device, the hydromagnetic propulsion mechanism produces smooth, continuous flow, reducing the risk of clot formation and promoting endothelial health.

### 5.3 Hemodynamic and Cardiac Function Optimization

The device's ability to assist in both systolic and diastolic function is a unique aspect of its design. By using nano-coils to enhance diastolic recoil, we were able to optimize the filling phase of the heart, which is often compromised in patients with heart failure with preserved ejection fraction (HFpEF). This is a significant advancement because it ensures that both phases of the cardiac cycle are effectively supported.

### 5.4 Durability and Long-Term Performance

The durability of the device is another critical finding of this study. In mechanical testing, the device demonstrated long-term functionality, exceeding the typical lifespan of current artificial heart technologies. The carbon nanotube-reinforced polymers used in the construction of the device contribute to its exceptional mechanical strength and wear resistance.

The development of the hydromagnetic artificial heart represents a significant advancement in the field of cardiovascular medicine. Traditional heart assist devices are limited by their invasiveness, risk of thromboembolism, and long-term complications. In contrast, the hydromagnetic artificial heart demonstrates superior biocompatibility, hemodynamic performance, and energy efficiency, offering a promising solution for patients with end-stage heart failure.

However, several challenges remain:

1. Miniaturization for Pediatric Applications: Current device size may not be suitable for pediatric patients, and efforts will be required to reduce the size without compromising performance.
2. Power Management: The wireless charging system is an important innovation, but extending the battery life for even greater convenience will remain a priority in future developments.
3. Regulatory Compliance: Adhering to international clinical standards and achieving regulatory approval will be essential for bringing this device to market.
4. Large-Scale Trials: While preclinical data is promising, human clinical trials are necessary to validate the device's long-term safety and efficacy.

Future research will focus on refining the device and conducting extensive clinical trials to establish its role in the treatment of heart failure. Additionally, ongoing efforts will aim to further optimize the device's biocompatibility and long-term durability to ensure its success in a clinical setting.

## 6. Conclusion

The hydromagnetic artificial heart has the potential to revolutionize the treatment of end-stage heart failure. By addressing key challenges such as biocompatibility, thrombosis, and hemodynamic stability, this device offers a promising alternative to heart transplantation. The results from preclinical trials are encouraging, and the device is now poised for further testing in human clinical trials. Continued innovation in the fields of biomaterials and cardiac mechanics will further improve its performance, with the goal of providing a lifesaving solution for patients with severe heart failure.

This study introduces a groundbreaking innovation in the field of cardiovascular medicine: the hydromagnetic artificial heart. With its potential to enhance cardiac output, biocompatibility, and durability, this device represents a transformative solution for patients with end-stage heart failure. As ongoing trials and future clinical studies continue to refine the technology, the hydromagnetic artificial heart has the potential to revolutionize heart failure management and improve patient quality of life on a global scale.

The hydromagnetic artificial heart represents an innovative and promising solution in cardiovascular medicine. This technology has the potential to improve the quality of life for patients with heart failure and serve as a viable alternative to traditional methods. With continued research and optimization, this approach could become a practical and reliable treatment option for heart disease [20].

The development of the World's First Hydromagnetic Artificial Heart represents a pioneering advancement in cardiovascular medicine. By integrating hydromagnetic propulsion, biocompatible materials, and wireless energy transfer, this technology overcomes the limitations of previous artificial hearts, offering a viable long-term solution for end-stage heart failure patients. Future clinical trials will be essential to validate its safety and efficacy in human applications.

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**Conflict of interest:** The authors declare that they have no conflict of interest.

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