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Next Generation of Artificial Heart: Permanent Maglev LVAD or TAH under 10k USDs

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Authors' contributions

This work was carried out in collaboration between both authors. Author KXQ designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author TJ managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The main obstacle of artificial heart in extending its applications in clinic has been its over high price rather than technical property. The new generation of artificial heart must enable the patients to be able to afford it. The author's permanent maglev pumps, both VAD (ventricular assist device) and TAH (total artificial heart), reduce their price to lower than 10 USDs, ca.1/10 of the third generation of artificial heart electric maglev pump. Moreover, the permanent maglev pump not only retains all the advantages of the electric maglev pump, but also has many innovations: its impeller vane was designed according to the streamlines in the pump, so that the blood damage was reduced as low as possible; It can produce either nonpulsatile or pulsatile flow; It can be made in LVAD or TAH, as wish. Besides, it needs no rotor position detector, no electric magnetic push and pull device for rotor suspension, and no feed-back controller for levitation. This is why its costs can remarkably reduced. Animal experiments for up to two months and clinical trial lasted 43 hours of permanent maglev LVAD demonstrated that the performances were excellent and perfect.

Keywords: Artificial heart; blood pump; electric maglev; permanent maglev.

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ABBREVIATIONS

VAD : Ventricular Assist Device
LVAD : Left Ventricular Assist Device
TAH : Total Artificial Heart

1. INTRODUCTION

The R&D of artificial heart has been over 50 years, Now it becomes routine that a patient could prolong his (her) life for several years with a heart pump. That means the technical properties of heart pumps enables the device to apply in clinic more extensively than at present. The main obstacle for extending the application of artificial hearts in clinic has been the over high price of the device, it costs ca. 100k USDs, almost 2 years' average income of the patients. The present situation is that the doctors need heart pumps to save the life of the patients, but the patients could not afford the device. This paper will present a new generation of artificial hearts, permanent maglev LVAD (left ventricular assist device) or TAH (total artificial heart), which cost only 1/10 of available heart pumps.

2. METHODS

2.1 Three Generations of Artificial Heart

As recognized at the present, the development of artificial heart can be divided into three stages:

1. The early diaphragm pump, which imitates the natural heart delivering the blood flow by volume change periodically;
2. The rotary pump, including centrifugal and radial as well as mixed-low pump, which assists or replaces the heart function by centrifugal forces of rotating blood;
3. The maglev rotary pump with electric-magnetic bearings.

These representative pumps of three developing stages have been respectively named as three generations of artificial heart. The third stage maglev pump, that is, the third generation of artificial heart, have achieved excellent results by now, the patients with it survived several years, because its technical advantages such as no contact between rotor and stator.

2.2 Requirements on Fourth Generation of Artificial Heart

Unfortunately, the electric maglev pump costs ca. 100k USDs, most patients can not bear the costs, thus the heart pump has been largely limited in clinical use.

The fourth generation artificial heart must have better technical performance than the third generation artificial heart electric maglev pump, meanwhile have much lower price than the latter, so as to enable every patient to afford the device.

2.3 Author's Progresses in Permanent Maglev LVAD or TAH

Since early 1980s, the author began to develop a Chinese rotary pump. After solving successively the problems of implantability, blood compatibility, pulsatility, reliability, etc, the bearing durability became the main question. Realizing that the electric magnetic bearing needs rotor position detect and feed-back control, which makes the device complicated and very expensive, the author insisted to develop a permanent magnetic bearing. Both axial and radial bearings were used in LVAD device (Fig. 1) [1], and then in a earlier developed impeller TAH (Fig. 2) [2,3,4].

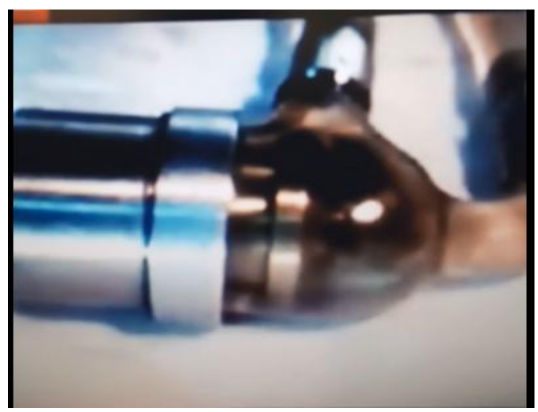

Fig. 1. Exhibition of a permanent maglev LVAD

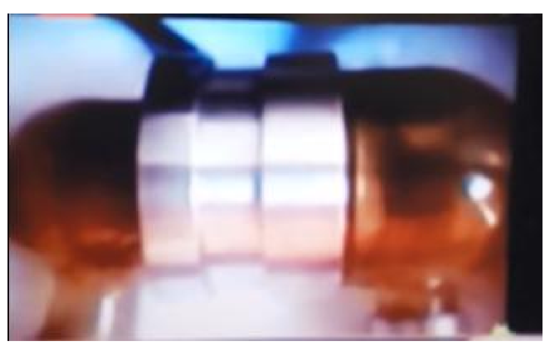

Fig. 2. Impeller TAH with permanent maglev bearings

2.3.1 Permanent magnetic bearings

Both axial and radial permanent magnetic bearings had been used in author's heart pumps. The axial bearing has two axial magnetized rings with different size, located side by side; and the radial bearing has two axial magnetized rings with different size too, one smaller ring locates in another bigger ring.

2.3.2 Impeller vane design

It's common sense that shearing stress of turbulence causes mainly the blood damage. The author designed impeller vane according to streamlines of blood flow in the heart pump, which were deduced by solving partial different equations analytically. Experimental visualization by use of PIV demonstrated that the blood cells pass through the impeller one by one, one after another, no crush and no stasis occurred in the pump [5]. The index of hemolysis is as low as 0.015, far lower than the allowable value.

2.3.3 Nonpulsatile and pulsatile flow

Most medical doctors prefer the pulsatile pump because the pulsatile flow can reduce the peripheral resistance and thus increase the circulation flow rate.

The author made the impeller pump pulsatile by changing the rotating speed periodically. In order to reduce the additional blood damage produced by pulsatile flow, the twist impeller vane were made to reduce the turbulence as the rotation speed changed [6,7].

3. RESULTS

3.1 Animal Experiments and Clinic Trial

The permanent maglev LVAD and TAH were evaluated on calves and then in clinic [8]. The animal experiments of permanent maglev LVAD lasted up to two months and the clinic application 43 hours. During experiments and clinic trial, the pump performances were excellent and perfect.

3.2 Permanent Maglev Stability: Earnshaw's Theory and Gyro-effect

Permanent maglev can not achieve stable equilibrium, most people including scientists point out, because a scientist named Earnshaw proved theoretically in 1839, that permanent magnetic system can not be stable if in static state and no other force except permanent magnetic force acting on the system. This theory can not be applied to the heart pump, however, because Earnshaw's two conditions, that is, static state and no foreign force, not be satisfied here.

Long-term investigation by the author demonstrated that if the permanent maglev rotary pump does not rotate or rotates but the speed not large enough, the levitation is unstable; if the rotating speed reaches a certain value, the rotor can be stable, because a so-called Gyro-effect occurs which stabilizes the rotor (Fig. 3) [9,10].

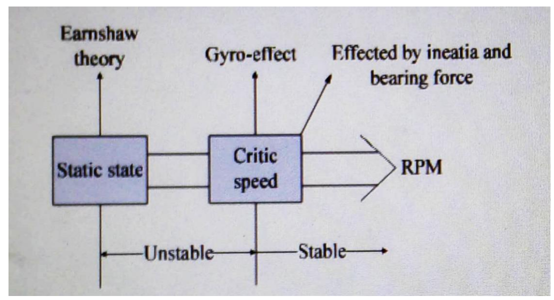

Fig. 3. Route chart to stabilization of permanent maglev heart pumps

4. DISCUSSION

Since 2000s there has been no decisive progresses in artificial heart because the over high price limited the profound applications in clinic. This article gives a way to overcome this obstacle. People have no idea at present to make a breakthrough in reducing the costs of artificial heart, but few scientists believe the author's cheaper and better permanent maglev heart pumps, because they will not believe permanent maglev could be stable. Some people had not read the article of Earnshaw, and could only know Earnshaw once said permanent maglev is unstable. This paper makes clear, why permanent maglev heart pump can be stable. It is expected more and more researchers will pay attention to the fourth generation of artificial heart.

5. CONCLUSION

A cheaper and better heart pump will largely extend its clinic applications and will save more patients who died until now because they were not able to use a over-high expensive device like an electric maglev pump. Permanent maglev pump with lower price and better technical property may change the current stalled situation of R&D in artificial heart [11]. The author is ready to cooperate with the readers for a bright future of artificial heart.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kun-Xi Qian. Permanent magnetic-levitation of rotating impeller: A decisive breakthrough in the centrifugal pump. J. Med. Eng. Tech. 2002;26(1):36-38.
2. Kun-Xi Qian. Toward an implantable total impeller heat. ASAIO Trans. 1987;33(3): 704-707.
3. Qian Kun-Xi. Basic technical problems of Chinese rotary heart pumps in engineering aspect. Hans Journal of Surgery. 2014;3: 34-47.
4. Qian Kun-Xi. Precondition for stabilization of permanent maglev rotator in centrifugal pump and turbine machine. 5th International Symposium on Fluid Machinery and Fluids Engineering. Soul, Korea; 2012.
5. Kun-Xi Qian. Theoretical deduction and experimental visualization of streamlines in mixed-flow impeller. Applied Mechanics and Materials. 2015;719-720.
6. Kun-Xi Qian. Pulsatile blood flow from impeller pump: A dream has come true. J Bio-materials Applications. 1994;9(2):158-177.
7. Qian KX, Jing T, Yuan HY, Wang H, Wang FQ, Zeng P. R&D of a pulsatile rotary heart pump imitating the native ventricle [J]. Applied Mechanics and Materials. 2012; 190-191:1234-1237.
8. Kun-Xi Qian. The animal experiments and clinical trial of impeller pump used as LVAD or TAH. Chinese J Biomed. Eng. 1998; 15(3):224-227.
9. Kun-Xi Qian. Route chart to stabilizing permanent maglev rotator. Advanced Materials Research. 2013;785-786:1586-1589.
10. Qian Kun-Xi. Methods of stabilizing a permanent maglev rotator in heart pumps and other rotary machines. Global Journal of Cardiovascular and Cerebro-vascular Diseases. 2014;2(3):831.
11. Teng Jing, Kun-Xi Qian. New generation of artificial heart. 2nd IERI International Conference on Medical Physics, Medical Engineering and Informatics. March 22-24, Tokyo, Japan; 2019.

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