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Non-invasive, non-blood-contact, pneumatic ventricular assist actuator based on wireless energy supply technology

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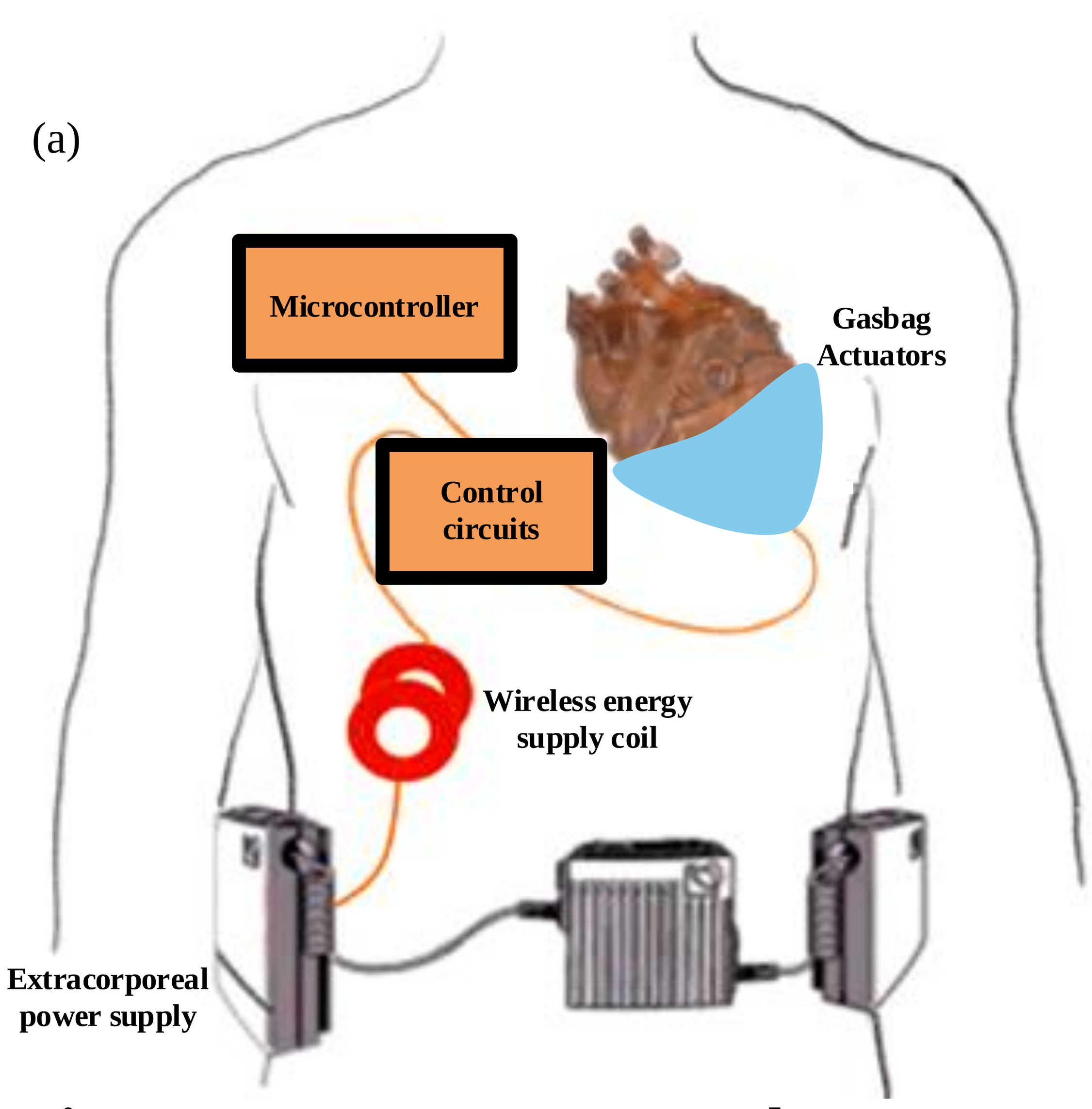
INTRODUCTION & AIM

When heart function is impaired by 30%-50%, noticeable heart failure symptoms can emerge. For end-stage heart failure patients, current ventricular assist devices can achieve a flow rate of 3-6 L/min, yet the invasive implantation methods pose significant risks of thrombosis and infection[1]. Non-blood-contact ventricular assist devices have primarily used pneumatic or hydraulic methods, which, despite generating high pressures, don't maintain non-blood-contact within the body. Our study has designed a wireless-powered pneumatic ventricular assist device, utilizing magnetic resonance wireless energy technology for a non-invasive approach, achieving non-blood-contact assistance. This approach offers an internal gasbag to compress the ventricle, offering a promising new treatment method for heart failure, but requires further research and validation.

METHOD



(b)

Assistive pressure	**2 Kpa**
Operating frequency	**1-2 Hz**
Working time	**12 Hour**
Flow rate	**0.6 L/min**

Fig. 1. Pneumatic ventricular assist actuator (a)and its design parameters (b).

The pneumatic ventricular assist actuator (Fig. 1 (a)) mainly consists of an external power source, a wireless energy supply unit, a control system, and an actuator. The design parameters of the device are shown in the Fig. 1 (b).

RESULTS & DISCUSSION

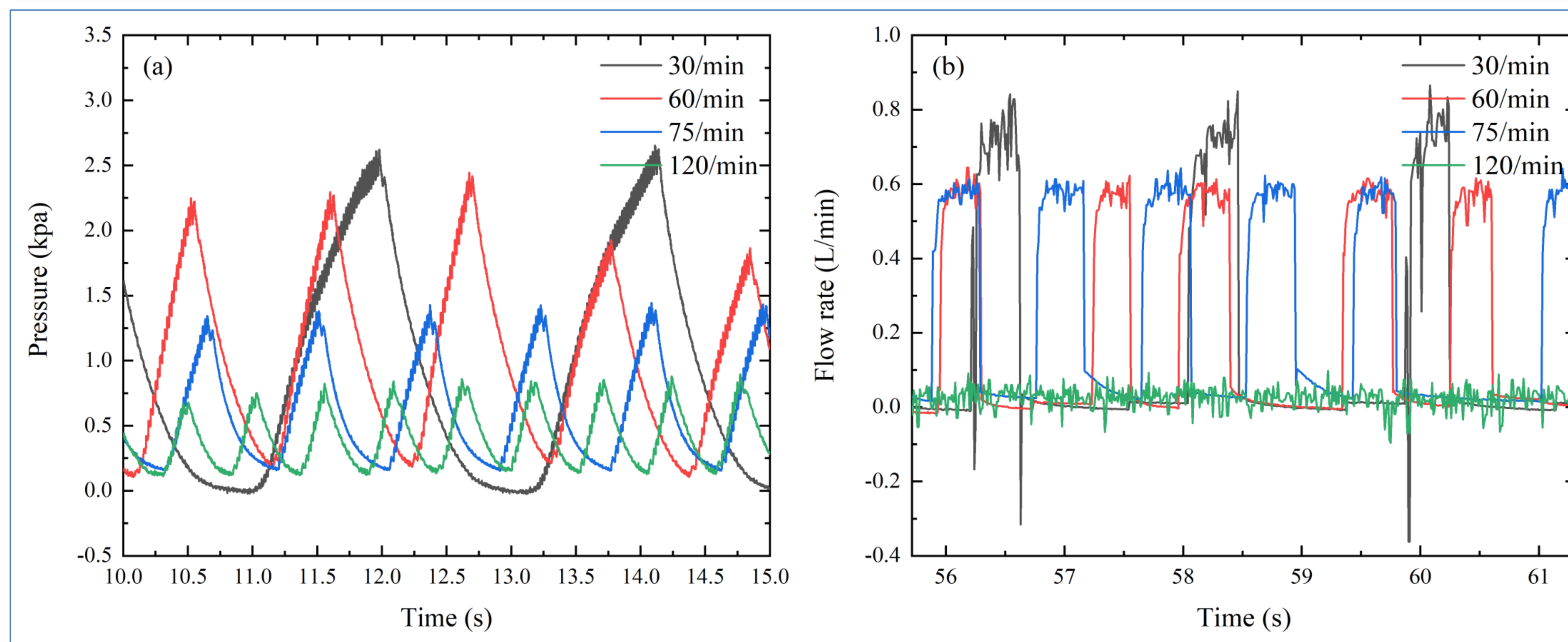


Fig. 2. Effect of pneumatic ventricular assist actuators of different frequencies, (a) Auxiliary compression results, (b) Aortic flow.

Fig. 2(a) shows that the actuator could achieve an assistive pressure of 2 kpa at human heart rates (60-120 beats/min), meeting 74% of the required assistive pressure for the human heart. After extended testing, the assistive effect showed only a 3.33% reduction, indicating that the actuator can operate effectively for long periods. Moreover, fig. 2(b) indicates that the device can deliver 15% of the normal blood flow rate of the heart at a frequency of 75 times per minute.

CONCLUSION

1. The device method can provide ***long-term, effective ventricular assistance*** in simulated human environments;
2. The experimental device can deliver 15% of the normal blood flow rate of the heart at a frequency of 75 beats/min.

FUTURE WORK / REFERENCES

Future work:

1. Reduce the temperature rise of wireless energy transfer;
2. The effectiveness of assistive devices will be tested by using real animal hearts.

References:

1. Weymann A, et al. Artificial muscles and soft robotic devices for treatment of end-stage heart failure. Advanced Materials, 2023, 35(19): 2207390.

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