

Harvesting energy from the heart wall motion – Device weight considerations

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Introduction

Primary batteries are used as energy source in active medical implants. However, the limited lifetime of batteries requires repeated replacement procedures associated with risk-bearing surgical interventions. To provide a continuous intracorporeal energy supply, we developed an energy harvesting device converting cardiac motion into electrical energy. The device – a modified autoquarz wrist watch – was fixated directly on the epicardial side of the ventricular wall. The impact of this additional mass on the heart was investigated to optimise weight and energy conversion efficiency.

Methods

A sternotomy was performed on a 60 kg domestic pig during an in vivo study. The energy harvesting device and a 9-axis inertial sensor were subsequently sutured onto the epicardium of the anteroapical segment of the left ventricle. The sensor was embedded into a plastic housing (4.5 g) carrying different additional loads from 0 to 20 g. A series of inertial measurements were acquired with a total load of 4.5 up to 24.5 g. These measurements were used as input for a mathematical model predicting the energy output of the harvesting device.

Results

The harvesting device generated a mean output power of 52 μ W. Acceleration measurements show a change in ventricular wall motion as a result of different load conditions: the physical work of the heart increased from 6 mJ at 4.5 g to 45 mJ at 24.5 g. This additional effort leads to higher forces acting on the harvesting device and ultimately results in an increased energy conversion. Simulations estimate a drop in harvested energy of more than 60% for a weight reduction from 24.5 g to 4.5 g.

Conclusion

Excessive overloading of the heart will interfere with cardiac function. However, we were able to load the heart with 24.5 g without observing any acute cardiac dysfunction. Furthermore, a heavier harvesting device favours the energy conversion.