Harvesting energy from the heart wall motion – Device weight considerations

A. Zurbuchen[1], A. Haeberlin[1,2], J. Schaerer[1], A. Pfenniger[1], R. Vogel[1,3]

[1.] ARTORG Cardiovascular Engineering, University of Bern, Bern, Switzerland
[2.] Department of Cardiology, Bern University Hospital and University of Bern, Bern, Switzerland
[3.] Department of Cardiology, Bürgerspital Solothurn, Solothurn, Switzerland

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 epicaridum of the anteroapical segment of the left ventricle. The sensor was embedded into a plastic housing (4.5 g) carrying different additional loads form 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 deivce.

Results

The harvesting device generated a mean output power of 52 µW. 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 disfunction. Furthermore, a heavier harvesting device favours the energy conversion.