A batteryless cardiac pacemaker powered by cardiac motion

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Introduction: The battery is one of the most limiting factors of modern pacemaker designs. Battery replacements require repeated surgical interventions with associated morbidity and costs. Alternative power sources not relying on stored energy become essential to improve a patient's quality of life.

Harvesting cardiac energy might provide a continuous energy source to power batteryless pacemakers. A possible mechanism to convert cardiac motion into electrical energy can be found in the automatic wristwatch: the movement of a person's wrist accelerates an eccentric mass in the clock housing. An integrated generator converts the rotation into electrical energy.

Methods: A harvesting device was derived from the clockwork of an automatic wristwatch. The harvester was then anchored on the heart thanks to a custom-made housing (total mass 16.7 g, figure 1). For an in-vivo study with a 60 kg domestic pic, a sternotomy was performed to suture the prototype onto the anteroapical part of the left ventricle. The harvesting device was connected to a custom-built single-chamber pacemaker. Finally, an epicardial bipolar pacing wire was used to deliver the pacemaker stimulus.

Results: The energy harvesting device supplied the pacemaker with enough energy to perform continuous VVI pacing (pacing threshold 1.0 V / 0.5 ms, sensing 9.8 mV, impedance 1279 Ω) at 130 bpm (pacing output 1.6 V / 0.8 ms). Simultaneously, the harvesting device generated a mean output power of 52 µW over an additional load resistor of 1 kΩ.

Conclusion: We demonstrated the feasibility of pacing the heart using its own mechanical activity. The harvested energy exceeded the power requirement of a modern pacemaker (~10 µW). Furthermore, we expect to increase the performance by optimising this first-generation prototype.

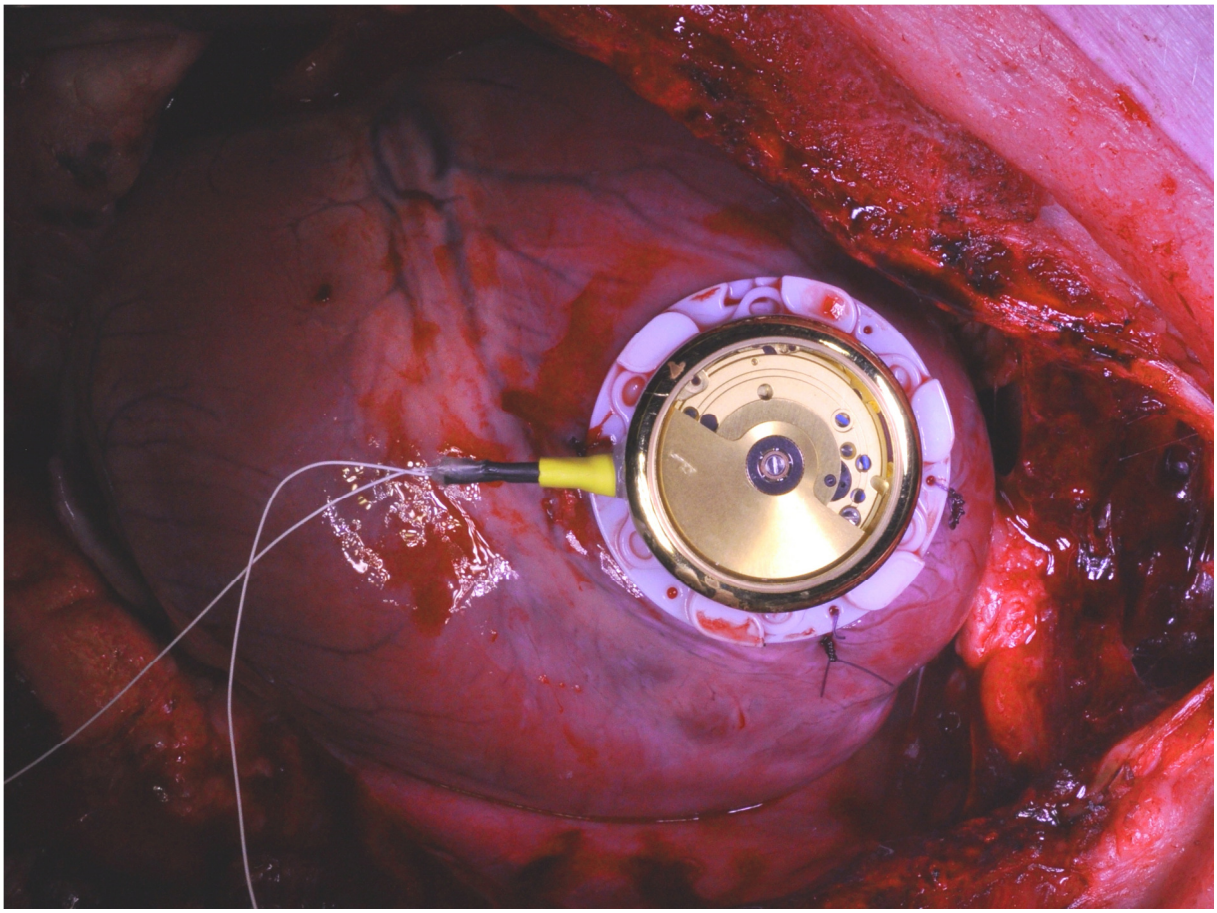

Figure 1: energy harvesting prototype on the left ventricle (antero apical)