Assembly and testing of a wireless, battery powered epicardial accelerometer for contractility sensing.

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Abstract

This work presents the assembly, biocompatible packaging and validation of a three-axis digital accelerometer to record the vibrations generated by the heart during its contraction. The device, designed to be stitched on the outer cardiac wall, is intended to provide information about heart contractility during acute and chronic in-vivo tests and could be used to monitor cardiac functionality in ischaemic patients. A dedicated system was developed (Fig.1) featuring a commercially available miniature three-axis accelerometer (BMA-280 Bosh Sensortec), a microcontroller with an integrated 433MHz wireless transceiver (CC430F5137, Texas Instruments) for data collection and transmission and a 64GBit flash memory (AT45db641e, Adesto) for data logging. The device is specifically designed for very low power consumption and is powered by a 3.3V coin cell battery with a capacity of 40mAh (cr1220, Panasonic). A tailored packaging technique was designed and implemented to minimize the immune response of the host organism while protecting the electronics from the aggressive body fluids. Two successive coatings were applied: a thin parylene-C layer was deposited by chemical vapour deposition and medical PDMS (NUSIL MED-6015) was moulded around the sensor. Three lobes in the PDMS package allow for stitching of the sensor on the cardiac muscle (Fig.2, Fig.3). The final device is 7mm thick and has a diameter of 24mm. The device was initially tested *in-vitro* for current leakage and water diffusion. Later, *in-vivo* performance was evaluated recording acceleration signals from different locations on the heart of a sheep during an acute test (Fig.4). Finally, the long term effects of the packaging strategy were investigated during a chronic experiment. Three sensors were implanted on different locations on the heart of a sheep and left in place for two months. At explantation, the sensors were nicely encapsulated in scar tissue making them adherent to the myocardium. No leakage of fluids in the sensors was observed.

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Figure 1: The contractility sensor before packaging.

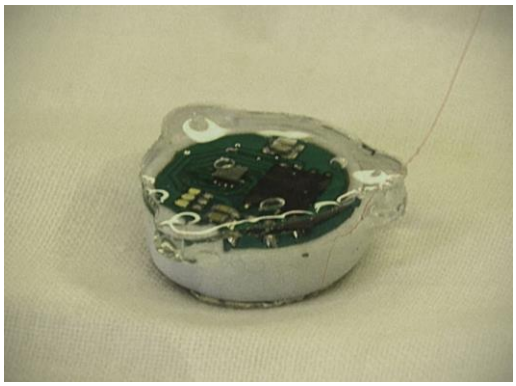

Figure 2: Sensor after biocompatible packaging

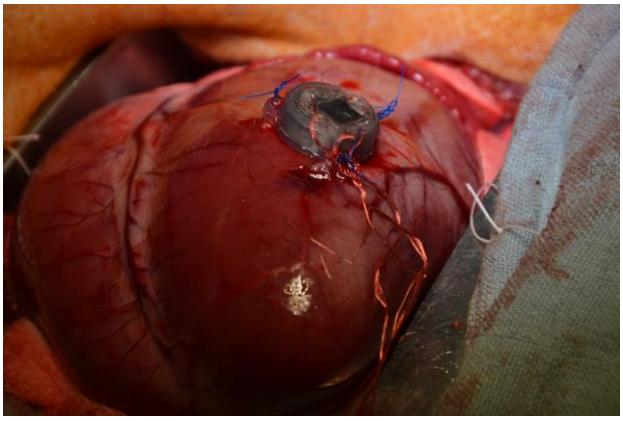

Figure 3: Sensor stitched on the heart of a sheep during an acute experiment.

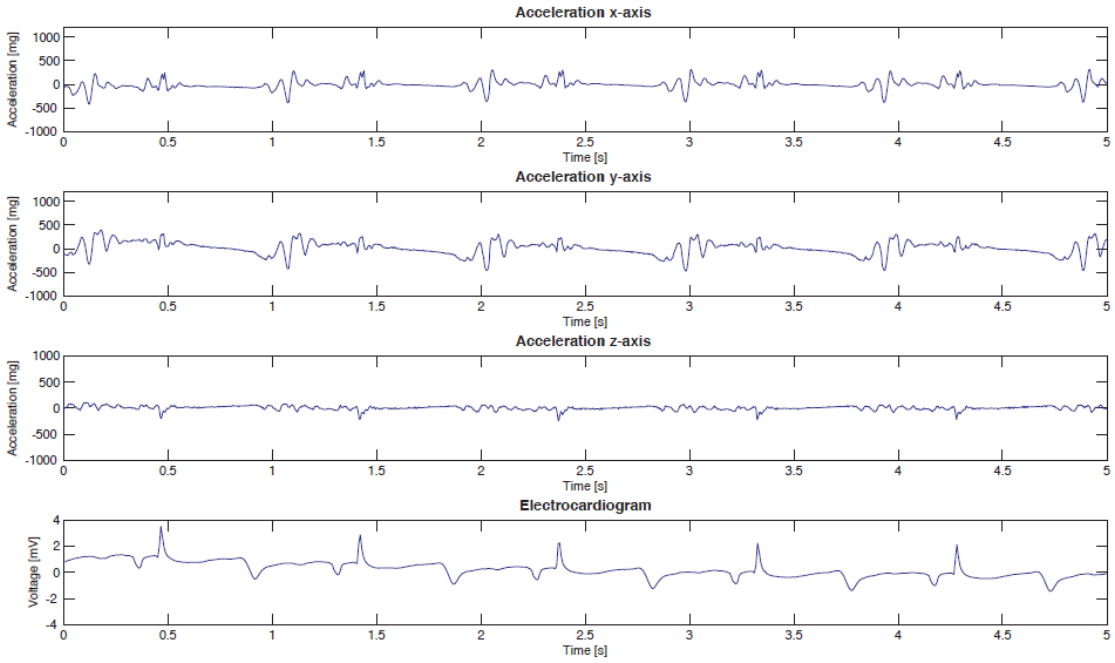

Figure 4: Five seconds window of the acquired data. From top to bottom: Acceleration along the X, Y and Z axis and ECG signal