Deteksjon av redusert blodtilførsel til hjertet ved hjelp av akselerometerteknologi

Detection of regional cardiac ischemia by accelerometer technology

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The Interventional Centre

Goals

1. Perioperative detection of *myocardial ischemia* in heart surgery patients
2. Measuring heart *function*
3. Online real-time monitoring (pacemacer-wires)

Collaboration

- **Medical**: IVS and Dept. of Cardiology, Rikshospitalet
- **Technology**: Vestfold University College, SINTEF
- **Commercial**: BMI (*Biomedisinsk Innovasjon AS)*

Contributors

- **The Interventional Centre:** Ole Jakob Elle, Steinar Halvorsen, Andreas Espinoza, Halfdan Ihlen, Tor Inge Tønnessen, Erik Fosse
- **Departement of Cardiology**: Halfdan Ihlen, Thor Edvardsen, Helge Skulstad
- **Vestfold University College:** Lars Hoff, Lars Fleicher, Craig Lowrie, Kristin Imenes

Background

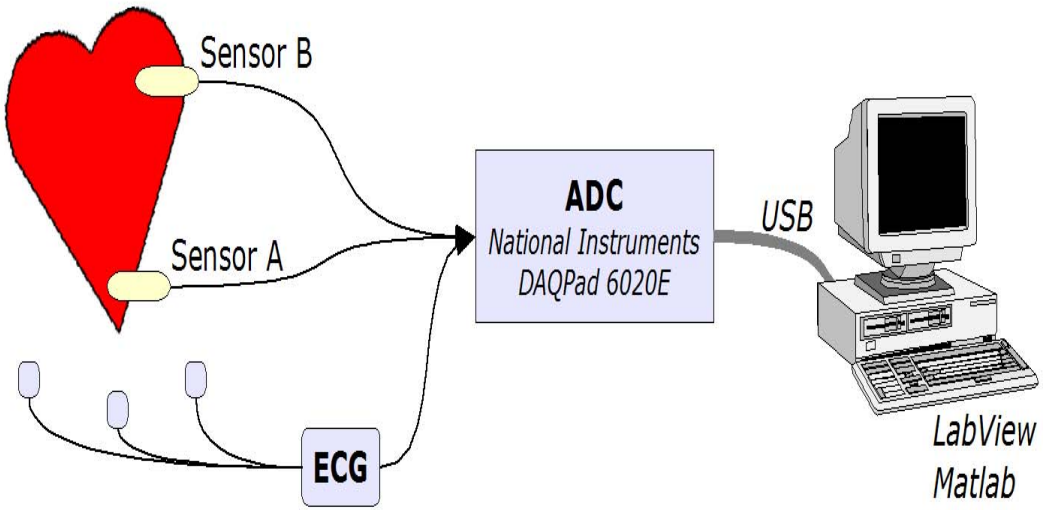
- Impaired coronary circulation causes heart muscle hibernation
- Immediate reduction in contractile work
- Occluded coronary graft cause regional movement reduction

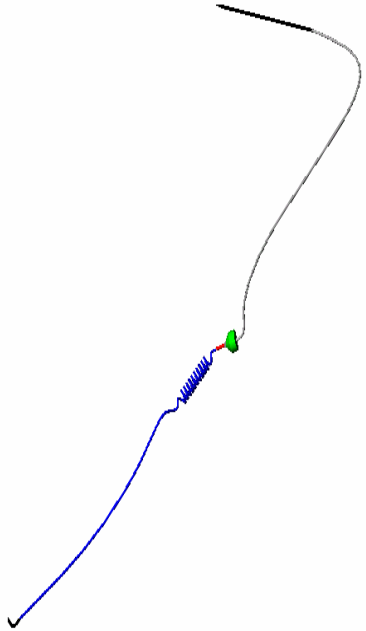
Cardiac Ischemia ➲ change in myocardial function and motion

The idea and hypotesis:

- 3-D accelerometers could detect regional systolic changes due to ischemia or reduced blood flow

Patented by *The Interventional Centre : WO 03/061473 A1*



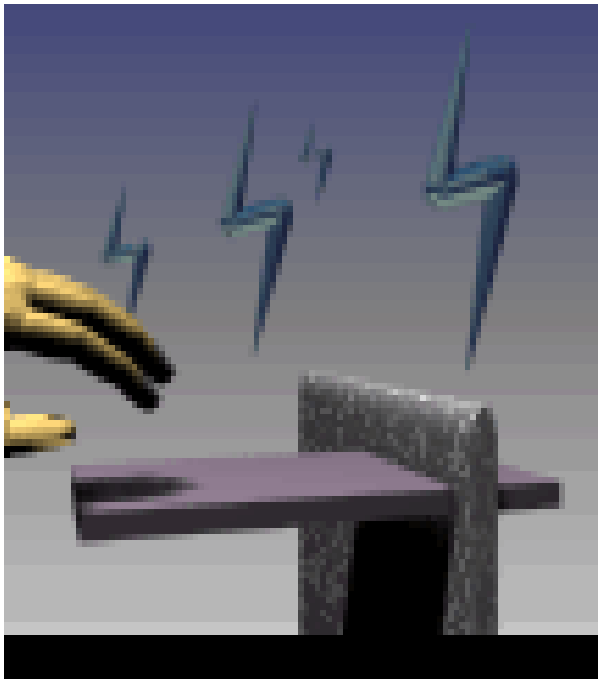


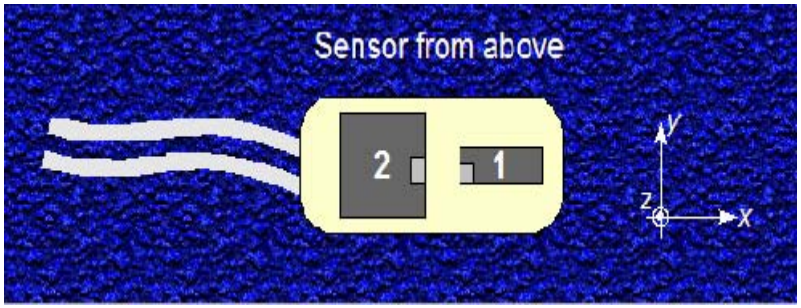
Piezoelectric material

- **Piezoelectricity—**

  Ability of certain materials to develop an electric charge that is proportional to applied mechanical stress.

- The effect is reversible.





Calculated Heart Motion

Acceleration

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Remove movements from respiration, patient movements etc.

Integrate twice wrt. time

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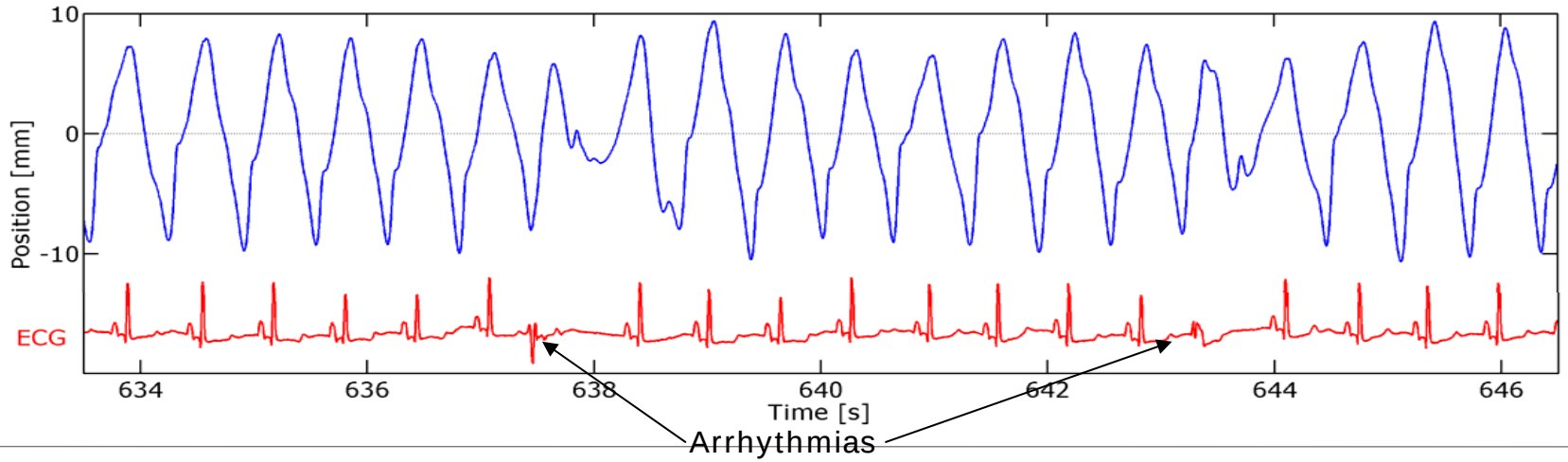
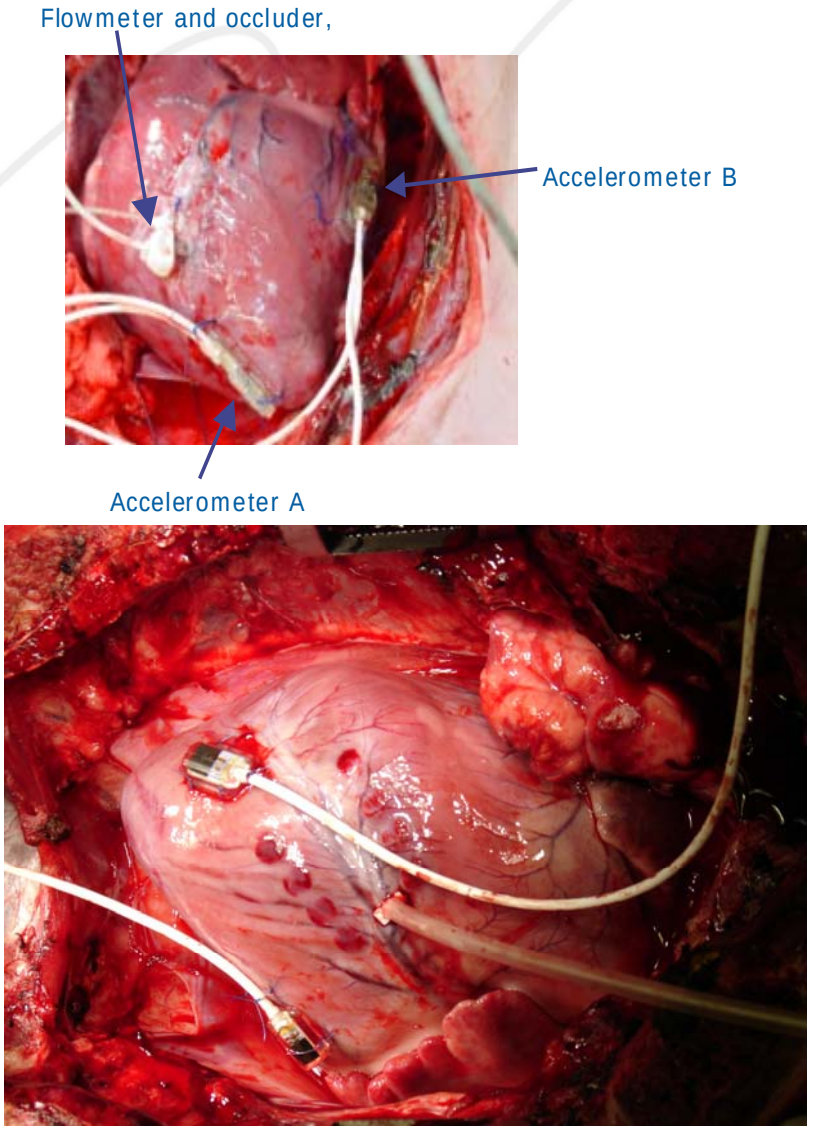
Heart position

- Nice curves. Noise hardly visible
- Arrhythmias easily identified



Experimental model:

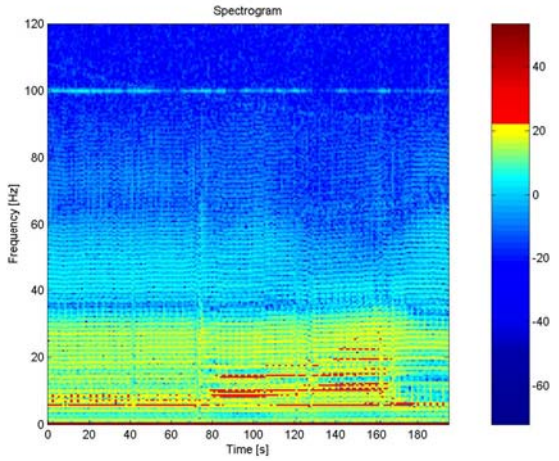
- ECG
- Hemodynamics
- Echocardiography
- Flow
  - aorta, LAD
- Accelerometers
  - LAD and CX region
- Occluder on LAD distally to the first diagonal branch (60 sec. LAD occlusion)

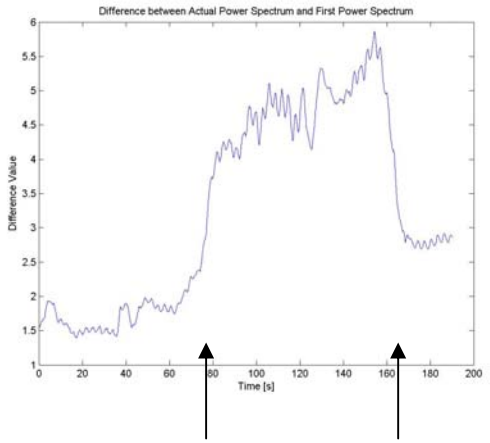


Data Analysis: Power Spectrum Difference

- Short-time FFT
  - 512 points moving window
- Difference relative first time window
  - Calculated for each window

$$\Delta SignalPower_{tot} = \sqrt{\sum_{n=0}^{512}(PS(n) - PS_{ref})^2}$$





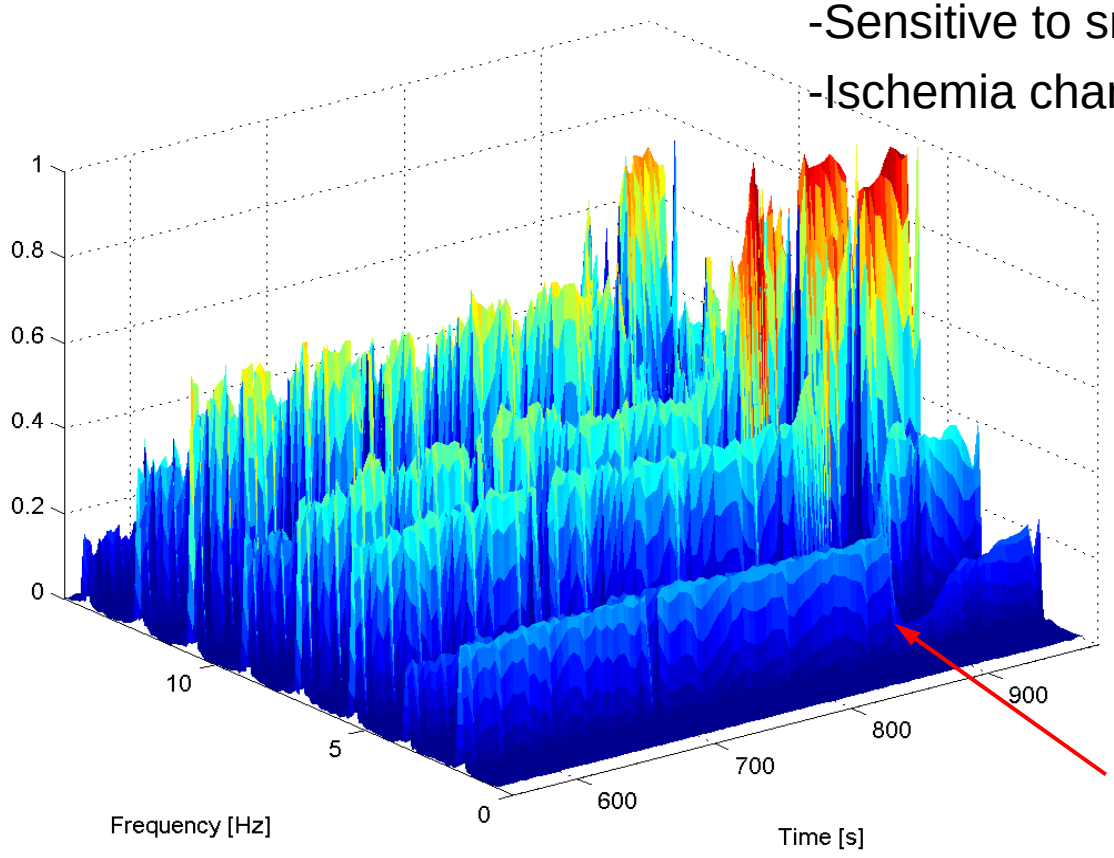
Occlusion Reperfusion

Frequency Analysis. *Spectrogram*

-Analysis of periodic signals

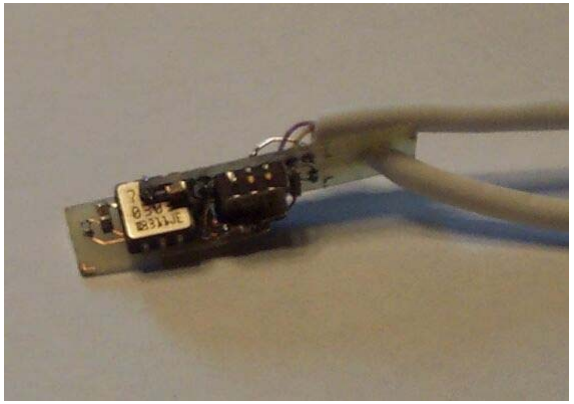
-Sensitive to small changes

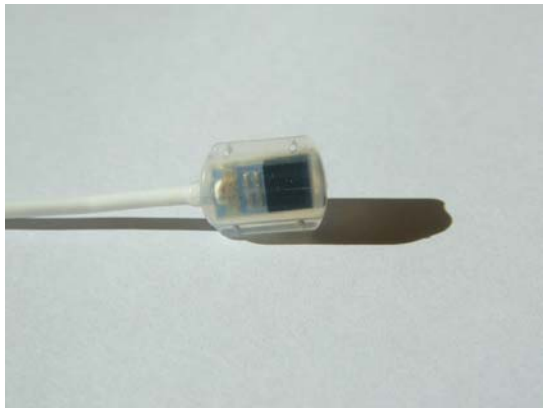
-Ischemia changes pattern

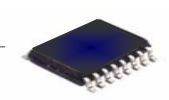


Miniature Sensor

- Prototype is too big
  - Useful experiments
  - Too big for final product
- Microsensor
  - Performance tuned to application
    - Good enough, small enough
  - Not general accelerometer
- What performance is needed?
  - Data from experiments
- Status
  - Two PhD students
  - Five designs in test production







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Status and future work

We have

- Prototype sensor, system for data acquisition
- Analysis algorithms that detect dysfunctional heart motion

We work on

- Improved algorithms to reliably identify dysfunctional heart real-time
- Improved sensor design/miniaturisation
- Biocompatible packaging
- Key questions related to specificity, sensitivity

Future work

- Human studies during beating heart coronary surgery
- Incorporation of a miniaturised accelerometer sensor into a temporary pace-maker electrode

Conclusions

Accelerometer sensors are suitable for monitoring heart movements

Occlusion of the LAD artery induces immediate regional changes in heart movement patterns that are detected by this sensor