New cardiac and breathing monitoring tool in MRI.

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PURPOSE

Hall sensors are used as input for gradient artifact reduction tools as adaptive filtering, to provide clean ECG trace [1]. Placed in the MR bore, this sensor gives additional information about respiration and heart pulse. We explored the possibility to use these data for patient monitoring during cardiac MRI.

METHODS

Hall sensor signals were measured with a Schiller Hall sensor device on 3 volunteers placed in a 3T G.E. MRI scanner (Fig. 1). Optical ECG sensors and standard pneumatic respiration belt were also used connected to the SAEC (Signal Analyzer and Event Controller [2]) for control.

The acquisition protocol consisted of free breathing and breath-hold periods with and without cardiac sequences.

The Hall sensor data were split in three sub signals: low (<0.5 HZ), medium ([0.5-30] Hz) and high frequency (>30Hz)

Quality of these signals was assessed with:

- The correlation between the low frequency sub-signal and the respiration signal from the belt
- The variation of distance between R-peak on ECG and pulse peak on medium frequency sub-signal

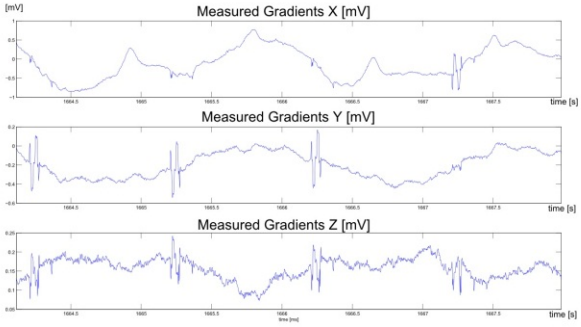

Fig.1 : *Example 3-lead signals of Hall sensor record. We can observe more than the fast gradient switching. Low frequency signals are present.*

RESULTS

The low frequency sub-signal was found well correlated (r^2=0.92) to the respiration signal from the belt (Fig2.a). The medium frequency signal showed a stable delay (179ms+-4.4%) between R wave and pulse peak (Fig2.b). Finally, the high frequency sub-signal shows the MR gradients as expected (Fig2.c), without any other signal than pure noise.

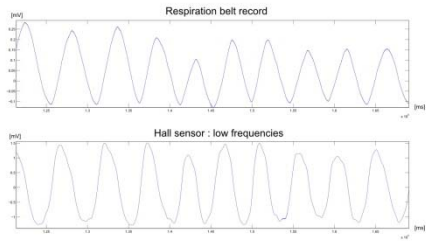

Fig2.a : *top- respiration belt signal*
Bottom- low frequency Hall sub-signal [<0.5Hz]

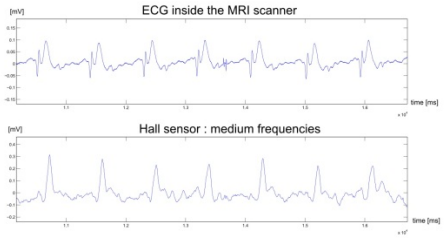

Fig2.b : *top- ECG*
Bottom- medium frequency Hall sub-signal [0.5Hz-30Hz]

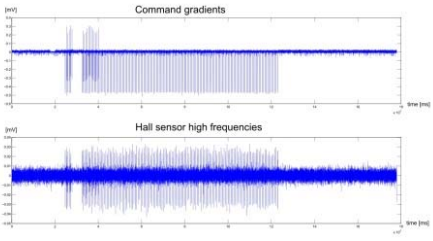

Fig2.c : *top- MRI gradients*
Bottom- High frequency Hall sub-signal [>30Hz]

DISCUSSION

We were able to measure a respiration signal and a pulse signal with a sensor originally designed for magnetic field measurement. Indeed, respiration and heart pulses cause modifications of the angle of the sensor, which is seen in the magnetic static field as a local magnetic gradient, and is therefore recorded by the sensor. These records give good results compared to clinically used monitoring signals, but the cardiac pulse signal depends on the patient erethism, and therefore may not always be observed. Moreover, as the Hall sensors measure a 3D vectorial information, the signal of interest (breath or pulse) can be amplified by combining the 3 leads for better monitoring.

CONCLUSION

Hall sensor in MRI provides a new way of measuring physiological signals without adding new sensors. These signals may be used to trigger the MRI sequences or to monitor the patient in the future. In our setup, the Hall sensors are integrated in the optical ECG sensors, making easy the patient preparation.

REFERENCES

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