MR compatible sensor for motion artifact corrected reconstruction method

L. ROUSSELET[1,2], M. LOHEZIC[2,3], D. MANDRY[2,4], C. PASQUIER[5], AND J. FELBLINGER[1,2]
[1]IADI, NANCY-UNIVERSITÉ, NANCY, FRANCE, [2]U947, INSERM, NANCY, FRANCE, [3]GLOBAL APPLIED SCIENCE LAB., GE HEALTHCARE, NANCY, FRANCE, [4]CHU DE NANCY, NANCY, FRANCE, [5]CIC801, INSERM, NANCY, FRANCE

INTRODUCTION:

Patient motion, especially respiratory and cardiac motion, leads to artifacts which could damage the quality of Magnetic Resonance Imaging (MRI) and make the resulting diagnosis less accurate. If such motion occurs during MRI acquisitions, it has been shown that, knowing this motion, it is possible to invert the process of artifact production and to reconstruct a motion compensated image [1]. For this purpose, a predictive model of patient motion would be helpful. Several models have already been proposed, based on linear prediction, using navigator echo signals as inputs [2]. GRICS (Generalized Reconstruction by Inversion of Coupled Systems) [3] is a reconstruction strategy for free breathing acquisitions which uses a motion model based on prior knowledge provided by external sensors, such as respiratory belts. Unlike navigators, external sensors are continuously available and do not require any dedicated pulse sequence.
Consequently, a new MR compatible external sensor has been developed which aims at measuring the acceleration of a localized region of the body. It gives additional information about patient respiratory motion during MR examination and has been integrated to the GRICS reconstruction as a physiological input to reduce motion artifacts and improve image quality.

MATERIALS AND METHODS:

Acquisitions were performed on an 1.5T and on a 3T MR scanner (Signa, GE Medical System Milwaukee, WI), on four healthy subjects (with a test protocol accepted by the ethics committee). For each subject, five short axis images were acquired with Black Blood Fast Spin Echo (BBFSE) sequences, one in breath-hold and four in free breathing. The parameters were the same for all acquisitions (TE= 35ms, TI=500-600ms, BW=125 kHz, matrix size: 512x512) except for the echo train length which was set to 16 for breath-hold acquisitions and 8 for free breathing. Two pneumatic belts were used as motion respiratory sensors (abdomen and thorax), and connected to a custom Maglife (Schiller Medical, France), a system for monitoring physiological parameters of patients during MRI. The external sensor, developed and based on acceleration measurements, was placed on the abdomen between the two respiratory belts (*Fig.1*). All physiological signals were acquired and recorded using SAEC (Signal Analyzer and Event Controller), a homemade dedicated hardware [4].

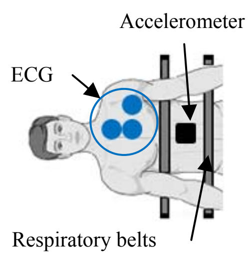

Fig.1: Sensor position

RESULTS:

Images taken from four different methods were compared: (i) images obtained by averaging the three free breathing acquisitions (*Average*), (ii) images acquired in breath-hold (*Apnea*), and images reconstructed using the GRICS algorithm (iii) with thoracic respiratory belt (*Belt*), (iv) with the proposed accelerometer based sensor (*Acc*). Image entropy, increasing with artifacts and noise, was used to assess image quality. Image quality was better with GRICS reconstruction combined with the described acceleration sensor than that obtained by averaging the three free breathing acquisitions and similar to that obtained in breath-hold or using the method proposed in [3] using respiratory belt (*Table 1*).

	Image entropy (less is better)			
			GRICS	
	Average	Apnea	Belt	Acc
Subject 1	4.05	4.22	4.02	3.92
Subject 2	4.53	4.44	4.43	4.48
Subject 3	4.6	4.61	4.48	4.44
Subject 4	4.1	4.27	4.03	4.01

Table 1: Quantitative assessment of image quality

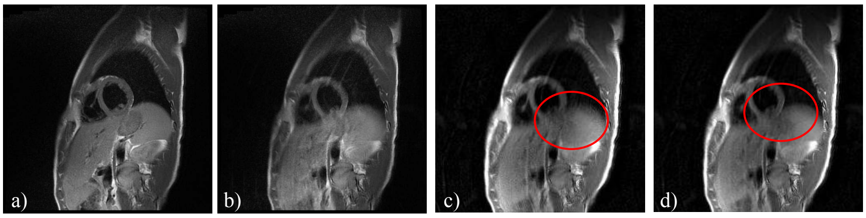

Fig.2 : Short axis imaging acquired a) in breath hold, in free breathing b) without post-processing, with c)GRICS reconstruction with respiratory belt, and d) GRICS reconstruction with accelerometer.

The images obtained with GRICS reconstruction was less blurred than the images in free breathing (*Fig.2*). Unlike the GRICS reconstruction with respiratory belt as input, the interface between cardiac muscle and liver seemed to be sharper.

CONCLUSION:

This study shows the possibility of integrating accelerometer to GRICS reconstruction as a physiological input. Accelerometer gives similar results to the respiratory belt. However, it is easier to install as it is not necessary to lift the patient. It would be interesting to combine several sensors including accelerometer to improve image quality. Moreover, the accelerometer could be placed at different points according to the organ of interest.

REFERENCES:

[1] Batchelor *et al.*, MRM. 54: 1273-1280 (2005) ; [2] Manke *et al.*, MRM. 50:122-131 (2003) ; [3] Odille *et al.*, MRM. 60: 146-157 (2008) ; [4] Odille *et al.*, IEEE T bio-med eng, 54: 630-640(2007).