Novel MRI-based Acquisition Methods

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Magnetic resonance imaging (MRI) is non-invasive, involves no ionizing radiation, and can provide detailed anatomical information of the nasal and pharyngeal airway [1]. MRI has the potential to visualize sites of airway collapse in patients with obstructive sleep apnea during natural sleep, but it is difficult to obtain such information with commercially available MRI pulse sequences and acquisition protocols. The main challenges are 1) simultaneous recording of relevant physiological signals (e.g., heart rate, oxygen saturation, respiration efforts, pressure, EEG), 2) ability to continuously run MRI scans for long periods of time without gradient amplifier overheating and radiofrequency tissue heating, 3) facilitating patient comfort to enable natural sleep, 4) ability to provide temporal resolution sufficient for resolving the airway collapse events, and 5) ability to provide spatial coverage of all airway regions of interest.

This talk introduces novel MRI-based acquisition technologies that have recently made it successful to obtain the characteristics of the airway dynamics and physiological signals during apneic events (for example see Figure 1) in pediatric patients with sleep related breathing disorders. The methods are based on 30-minute continuous 2D real-time MRI scans along with simultaneous recordings of the cardiac and respiratory signals, pressure from a facial mask port, and improved temporal resolution using parallel imaging and compressed sensing. In addition, an external setup for airway occlusion has been integrated into the MRI acquisition protocols [2]. The setup allows for occlusion of the airway during either wakefulness or sleep, leading to measurement of airway compliance as an indicator of pharyngeal airway collapsibility. Data acquired during occlusions will serve for the modeling and phenotyping of different characteristics of sleep related breathing disorders. Finally, recent work on 3D real-time MRI acquisition of the upper airway during sleep is presented.
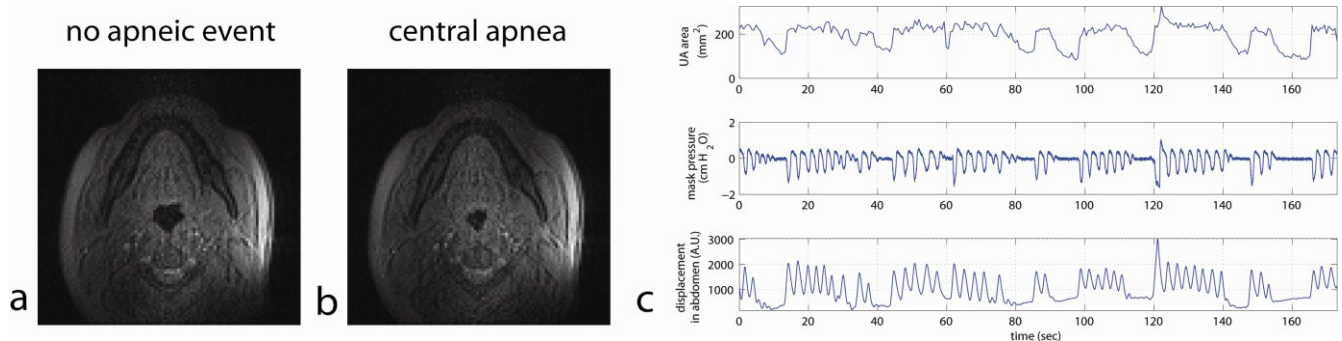

Figure 1. A result from a 14-year old subject with sleep related breathing disorder. (a,b) Axial MR image frames representing that there is (a) no apneic event and (b) central apnea. A marked reduction of the airway cross-sectional area is observed in (b). (c) Plots of cross-sectional area, pressure from a mask port, and displacement of a respiratory bellows simultaneously recorded with MRI.

REFERENCES

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