Real Time Sleep MRI and Physiologic Monitoring of Patients with Obstructive Sleep Apnea

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Introduction

Sleep disordered breathing is a spectrum of syndromes comprised by snoring, upper airway resistance, and obstructive sleep apnea (OSA). OSA is a very common disorder with an incidence as high as 24% of males [1]. Airway obstructions in OSA can cause lack of sleep that limits productivity at best and causes death at worst. Current standards of OSA diagnosis involve an attended overnight polysomnogram (PSG) under as natural conditions as possible, conventional X-ray studies and sometimes sleep endoscopy. These methods are compromised by their inability to document the actual anatomical abnormality under sleep conditions and the inability to provide physiological information in relation to specific obstructions. A potential solution to these limitations is to combine real-time MRI with simultaneous physiological measures provided by a medical device currently used in outpatient OSA care (Watchpat WP100, Itamar, Caesarea, Israel) [2]. Real-time MRI can display dynamic anatomic information about the upper airway in a sleeping patient and the Watchpat can provide simultaneous physiologic measures like pulse, pulse arterial tone, oxygen saturation, and whether the patient is asleep. The purpose of this study was to determine if the conditions underlying OSA can be more accurately specified.

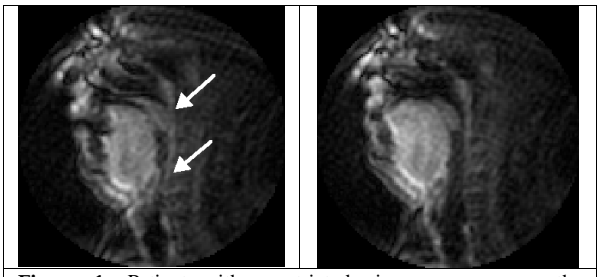

Figure 1: Patient with constricted airway space near the epiglottis and soft palate (left, denoted with arrows), and open posterior airway space (right).

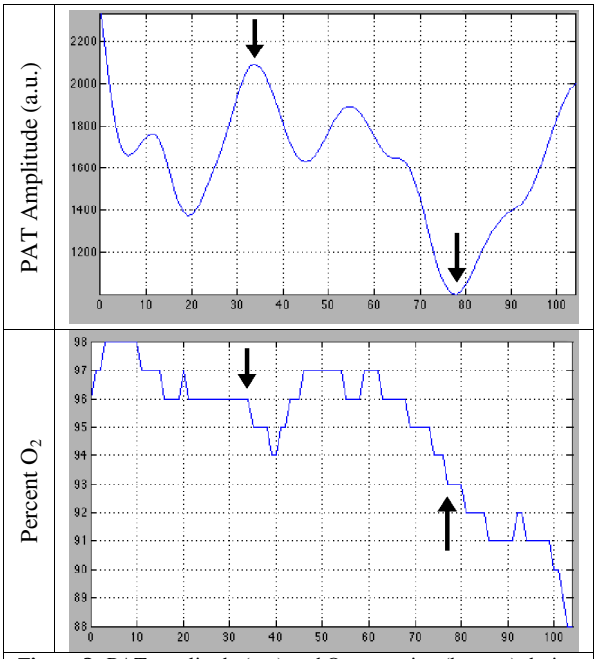

Figure 2: PAT amplitude (top) and O_2 saturation (bottom) during patient sleep over time in seconds. The left and right images of Figure 1 are marked with arrows (left arrow = left image).

Methods

Patients with mild to severe OSA were continuously imaged within a 0.5T Signa SP MRI scanner (GE Healthcare, Waukesha WI). This scanner's 60 cm open design facilitates natural sleep and allows application of additional measurement devices. A circular receive coil was placed over the patient's face from nasion to below the chin. The Watchpat WP100 device was coupled to the right arm along with a pulse oximetry probe to the index finger. The internal clock of the Watchpat was synchronized with the MR imaging time sequence. The patient was asked to sleep without use of any pharmaceuticals. Images were acquired using the RTHawk real-time system [3] and 2D spiral sequence with 6 interleaves that was capable of acquiring at a gradient hardware limited maximum of 5.5 fps. A sagittal view through the patient's midline of the upper airway with a resolution of 2.6 x 2.6 x 5 mm over a 20 cm FOV was selected.

Pulse rate, pulse arterial tone (PAT) amplitude, and concentration of blood oxygen were measured continuously and registered to the MRI video. Images were qualitatively analyzed to identify site or sites of obstruction and the associated changes in the physiological measures.

Results

Ten patients were successfully imaged. Based on the physiological data, all fell asleep for a period of time during the ninety minute session. Tongue and soft palate movements during an airway obstruction occurred at a much slower rate than the imaging frame rate, which allowed accurate continuous monitoring for respiratory obstructions. Representative images of the airway while unobstructed and obstructed are shown in Figure 1. Note in the first image that the airway is constricted and obstructed at multiple sites.

Physiological data from the WatchPat synchronized to the MR images in Figure 1 are shown in Figure 2. Note the large changes in PAT and O_2 saturation associated with the respiratory event. Trends in O_2 saturation may also be useful in quantifying the duration of a respiratory event. When the airway is obstructed, the blood oxygen saturation decreases until the airway reopens sufficiently. The duration of the decrease in O_2 in Figure 2 demonstrates the length of time a respiratory event can occur. Even though at 78 seconds the patient appears to have an open airway space, the affect of the obstruction is still present because the reduced oxygen saturation has not yet returned to the pre-obstruction level.

Conclusion

Simultaneous real-time MRI scans and Watchpat recording while sleeping appear to be an innovative and improved method for more precisely characterizing airway obstructions for patients with OSA. The changes in PAT amplitude and blood oxygen level could be useful in diagnosis, although longer video sequences are needed to ensure the capture of an entire respiratory event. This approach is also is valuable for planning surgical treatments, potentially improving the success of these procedures.

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