Real-time MRI with Synchronous Polysomnography of the Upper Airway in Patients with Obstructive Sleep Apnea.

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PURPOSE: To describe a real time, sleep MRI protocol that evaluates dynamic, upper airway changes with synchronous polysomnography evaluation to determine sleep stages and apneic episodes in patients with obstructive sleep apnea.

OUTLINE OF CONTENT:

(1) Clinical Background: Obstructive sleep apnea (OSA) is a clinical disorder characterized by occlusion and/or narrowing of the upper airway occurring during sleep which results in breathing cessation (apnea) or decreased airflow (hypopnea). Subsequent, brief awakenings can occur up to 500 times per night, resulting in severely fragmented sleep. OSA is linked to increased motor vehicle accidents and numerous health complications.

The overnight "sleep study" or polysomnogram (PSG) is the gold standard examination to diagnose OSA where electroencephalographic (EEG) and other physiologic measurements are used to confirm and determine stages of sleep at the time of apneas and/or hypopneas. **However, *PSG does not identify or characterize the location(s) and extent of airway collapse.***

Most surgical and minimally invasive OSA treatments have success rates of only 35-60% [1] with therapy aimed at decreasing collapsibility by either increasing airway diameter and/or decreasing compliance. The most critical question to answer for a surgeon prior to performing OSA surgery is to determine the likely site(s) and degree of airway obstruction. Current pre-operative evaluation is performed while the patient is awake and in the upright position, or in an artificial, (drug-induced) sleep; these may not always accurately reflect airway changes and collapse produced by natural sleep.

A major reason for the poor clinical outcomes has been attributed to inaccurate airway obstruction localization. Improved pre-surgical selection is necessary for optimizing surgical planning. Typical sites of airway collapse include the soft palate, base of tongue, and lateral pharyngeal walls. [2] Therefore, our sleep MRI protocol describes an optimal examination with synchronous, multiplanar upper airway imaging with PSG information to confirm sleep and apneas.

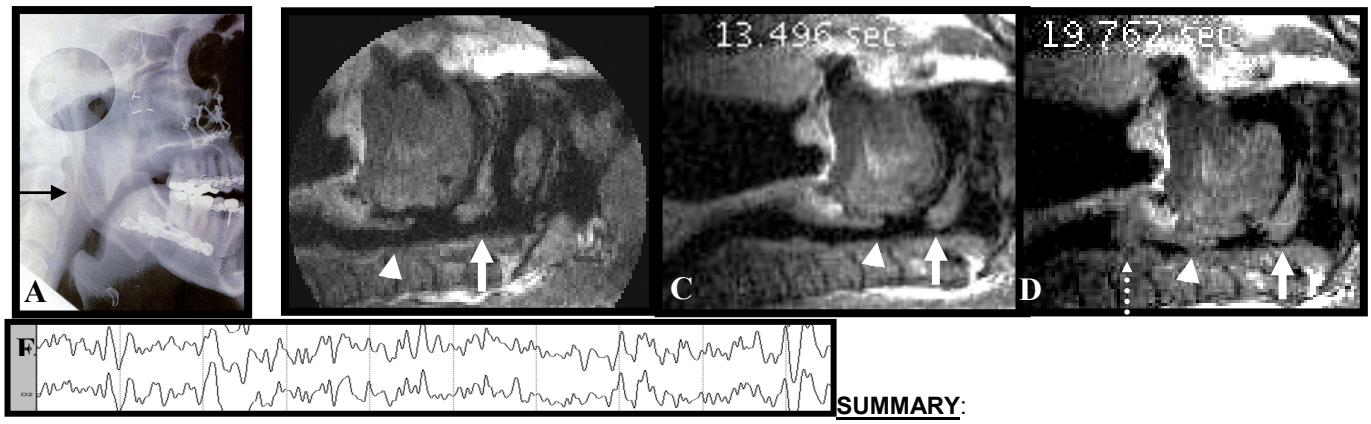
(2) Sleep MRI with polysomnography protocol: Subjects scanned awake and then up to 4 hours of natural sleep.

(A) Using the RTHawk real-time system (HeartVista, Inc. Palo Alto, CA) at 3T (Signa® HD, GE Healthcare, Waukesha, WI), we developed a multiplane, partial k-space GRE sequence that can simultaneously acquire three independent slices. Typically the slice locations acquired were the sagittal midline and axial slices at the base of tongue and soft palate. The planes are interleaved every TR and could be turned on or off as desired. Each plane is acquired with 83 phase encodes, 25 x 25 cm FOV, 1.95 x 1.95mm resolution with an inherent TR of 8ms. The inherent temporal resolution was 3 slices every 2 seconds, although faster resolutions were achieved using sliding window reconstructions. Two 5" surface coils were placed bilaterally over the neck. In addition, we implemented a multi-touch interface to simplify user interaction and on-the-fly adjustments.

(B) Polysomongraphy. 1) Electroencephalography (EEG). MRI-compatible hardware (to record 64-lead EEG recordings (Neuroscan, El Paso, TX). 2) Physiologic data recording (Non-EEG) of: electromyograms (EMG), electrooculogram (EOG), airflow (nasal, oral), chest/abdomen wall movement (respiratory bellows), oxygen saturation, heart rate.(BIOPAC Systems Inc., Santa Barbara,CA)

(3) Example of clinical utility of sleep MRI with polysomnography:

This is a case of a 51-year old male with persistent OSA with failed OSA surgery. (A) Lateral cephalogram demonstrates surgical changes of plates, screws, and wires. Note: widely patent retro-palatal airway (arrow) while patient is awake. (B) Real time MRI demonstrates open airway at base of tongue (arrowhead) and palate (arrow) while patient is awake. (C) MRI demonstrates early airway collapse of the airway at the soft palate (arrow) with patent tongue base airway (arrowhead). (D) 6.2 seconds later, complete collapse identified at the level of the soft palate (arrow), tongue base (arrowhead), and glottis (dashed arrow). (E) EEG confirming stage N2 Sleep during C and D. **CLINICAL IMPACT**: **Surgeon did not expect any obstruction at soft palate level, but after review of the Sleep MRI examination, his surgical approach was changed to include treatment at this site.**



SUMMARY:

Anatomic evaluation of the upper airway with real time MRI with synchronous polysomnography can successfully be performed. Future studies are necessary but sleep MRI may improve pre-operative OSA planning and clinical outcomes through direct identification of the site(s) and severity of upper airway collapse.

[1] Kezirian EJ, Goldberg AN. *Archives of otolaryngology--head & neck surgery* 2006;132:206-213.
[2] Schwab RJ, Gupta KB, Gefter WB, et al. Am J Respir Crit Care Med 1995;152 (5 Pt 1):1673–1689.