The Association Between Obstructive Sleep Apnea and Airway Anatomy/Flow In Turner Syndrome Patients

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Background: In Turner Syndrome patients, craniofacial abnormalities and decreased pharyngeal tone increase the risk of sleep-disordered breathing (SDB). Obstructive Sleep Apnea (OSA), a severe form of SDB, is more common in TS patients relative to the general population. Diagnoses of OSA are often missed, and improved diagnostic technologies are necessary to institute corrective therapies in TS patients with concurrent OSA. Computational Fluid Dynamics (CFD) modeling can allow clinicians to simulate airflow dynamics in the upper airway, and characterize airflow problems in SDB/OSA.

Hypothesis: Abnormal airflows result from anatomic and functional anomalies in TS; computational modeling will determine whether these airflows result in SDB/OSA.

Aims:
(1) Use computational modeling to characterize airway flow dynamics in TS patients
(2) Correlate these CFD results with corresponding polysomnography data

Methods: TS patients from CCHMC were considered eligible if they answered 8 or more questions as abnormal on the Pediatric Sleep Questionnaire. A CCHMC 3T MRI scanner collected anatomical data from the airways of these patients. Axial MRI images from each patient were used to reconstruct 3D airway models spanning from the hard palate to the base of the epiglottis. Computer simulations were done to predict peak inspiration and peak expiration phases for typical breathing cycles, and airflow resistance was determined. Polysomnography data was collected at the CCH Sleep Center.

Results: Using CFD modeling, the upper airways of a 12 year-old TS patient were analyzed. The airway volume was 15.5 cc and length of computational model about 8 cm. Maximum axial velocity during inspiration and expiration was 4 m/s at the soft palate tip, and maximum shear wall stress was 1.4 Pa (observed on the anterior side at the tip of the epiglottis during inspiration and expiration). Minimum wall static pressure was ~ -1.3 Pa. Polysomnogrophy data for this TS patient is pending.

Summary/Conclusions: After obtaining a CFD model of a TS patient, we expect to find substantial anatomical differences in the age-matched control. Anatomical differences may produce significant airway dysfunction in a TS patient, which we will assess through polysomnography data. Further CFD modeling and polysomnography analysis of TS patients, followed by comparison to their age-matched controls, will allow us to link pharyngeal structural irregularities to SDB/OSA, and consequently determine the efficacy of CFD in predicting SDB/OSA.

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