Introduction

The prevalence of obstructive sleep apnea (OSA) in children with Down syndrome (DS) ranges between 30 to 65%. The complexity of the pathogenesis of OSA in these children is illustrated by a high incidence of residual OSA after adenotonsillectomy (AT) and by a frequent need for additional treatment. The aim of this pilot study was to investigate whether the volumes of the upper airway (UA) obtained by an ultra-low dose CT scan of the UA combined with computational fluid dynamics (CFD) could provide a better understanding of the UA in these children with OSA with an ultimate goal of improving treatment outcome.

Methods and materials

Children with DS diagnosed with OSA by polysomnography were prospectively recruited. All children got a thorough evaluation in terms of history, clinical examination and all underwent an ultra-low dose CT scan of the UA while being awake. 3D reconstructions were built from these images (Figure 1) and were subdivided into a large number of discrete elements and were further analyzed by CFD. Specific airway volumes corresponding to certain zones were measured (Figure 2).

Decisions on the need and type of surgery were based upon findings during drug-induced sleep endoscopy. A second polysomnography was performed 3-6 months after treatment in a subset of patients.

Results

34 children without a history of tonsillectomy or AT were included: 16M/18F, age=6.2±4.7 y, BMI=18.4±4.3 kg/m² and obstructive apnea/hypopnea index (oAHI) of 16.125(5-70) events/hour. 28 (82%) children were diagnosed with moderate-to-severe OSA (oAHI>5 events/hour). Analyses were repeated for children with age≥6 (n=23) to OSAS related differences in the craniofacial structure in this group.

SaO2max correlated with the volume of the total UA (r=0.40, p=0.024), zone1 (r=0.38, p=0.013), zone2 (r=0.52, p=0.003), zone4 (r=0.44, p=0.012), UA conductance (r=0.06, p=0.001) and minimal area (Amin) (r=0.47, p=0.007). The first zone of minimal area was located in zone3 in 35% of patients and there were significant positive correlations between neck circumference and UA volumes and UA resistance, like that with body mass index. Furthermore, there was a significant negative correlation between tonsil score and UA volumes. For patients with age≥6, SaO2max correlated with zone3, UA conductance and Amin. Also, there were negative correlations between the arousal index and zone1 (r=0.53, p=0.037) and between objective snoring and zone3 (r=0.47, p=0.024), UA conductance (r=0.52, p=0.011) and minimal area (r=0.55, p=0.007).

A treatment modality was proposed based on findings during drug induced sleep endoscopy (Table 1). 20 children underwent ATE (with or without leukotrien receptor antagonist nasal steroids) and 75% of them underwent polysomnography 3-6 months after ATE. Persistent OSA was diagnosed in 13/15 patients, 10/15 had a oAHI decrease of more than 50%. A significant negative correlation between the oAHI after treatment and zone4 and oAHI after treatment and zone5 (r=-0.60, p=0.518) was observed. There was a negative correlation between the decrease of oAHI and zone4 (r=-0.58, p=0.025) and zone5 (r=-0.64, p=0.011). Children who had a decrease of 50% or more in oAHI had a larger zone3, zone4 and zone5. Nineteen of the treated patients had an age≥6. In this group there was a significant negative correlation between oAHI after treatment and zone3 (r=-0.48, p=0.04), UA conductance (r=-0.58, p=0.009) and the Amin (r=-0.48, p=0.037).

Despite of previous findings from our group there was no baseline correlation found between oAHI and imaging parameters in this group.

Conclusions

This pilot study in children with DS and OSA showed only a significant correlation with the degree of hypoxia during sleep and imaging parameters. There also was a correlation between clinical markers and UA volumes. After treatment, 69% of the children with ATE had a decrease of 50% or more in oAHI. Larger volume in zone4 and zone5 were associated with better outcome after ATE, possibly because less tongue base obstruction in these patients. In the subset of children younger than 6 years old, there was a relationship between volume in zone3 (the overlap region) and better treatment outcome. This implies that children with a more constricted airway were less likely to have a substantial decrease in oAHI after treatment. The predictive value of this promising technique in improving treatment outcome needs to be studied in a larger population.