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Polysomnographic results of prone versus supine positioning in micrognathia

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ABSTRACT

Background: Children with micrognathia commonly present with upper airway symptoms and are at risk for developing obstructive sleep apnea (OSA). Prone positioning is widely used as first-line management for micrognathic children with obstructive symptoms. The aim of the present study was to document the effect of positioning on oxygenation and upper airway obstruction as measured by polysomnography (PSG).

Methods: Three children with micrognathia from two institutions underwent PSG in both the prone and supine position.

Results: Patient ages were 1 week, 3 months, and 7 months. Supine obstructive apnea–hypopnea indices (oAHI) were severe for all 3 children, with a mean of 21.9 events/hour (range 16.8 to 26.3). In the prone position, the oAHI significantly improved in 2 of 3 children, with a mean of 5.1 events/hour (range 0.3 to 10.3). The frequency of central apnea events increased in 1 child following supine positioning. Nadir oxygen saturation improved in 2 of 3 children and remained within normal limits in the third.

Conclusions: This is the first report of the effect of positioning on changes in PSG indices of micrognathic children. Improvement in obstructive PSG indices occurred with prone positioning, though OSA persisted in 2 of 3 children. The effect of positioning on central apnea was unclear. In light of these findings, we recommend that routine PSG be considered in micrognathic children undergoing prone positioning for definitive therapy of upper airway obstruction.

1. Introduction

Sleep disordered breathing (SDB) and obstructive sleep apnea (OSA) represent a continuum of disorders characterized by abnormal respiratory patterns [1–3]. These disorders range from simple snoring, caused by intermittent increases in upper airway resistance, to complete obstruction. Children with OSA are at risk for developing neurocognitive impairment, hyperactivity, inattentive behavior, and poor school performance [4–6]. Risk factors for the development of OSA include black race, male gender, premature birth, down syndrome, cleft palate, and craniofacial abnormalities, including micrognathia [7–10].

Micrognathic children commonly present with upper airway obstruction, and management decisions are based on the severity of the obstruction. For symptomatic patients, nonoperative approaches include placement of a nasopharyngeal airway and prone positioning. These measures aim to reduce obstruction at the retroglossal airway by bringing the tongue forward [11]. Based on subjective clinical assessments of obstructive symptoms and feeding difficulty, prone positioning has been shown to be

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successful in up to 60% of micrognathic children [12–14]. However, there have not been any studies describing the effect of prone positioning on oxygenation and upper airway obstruction as measured by overnight polysomnography (PSG). The aim of the current study was to identify how PSG obstructive indexes change with supine versus prone positioning in micrognathic children. We hypothesized that prone positioning would be associated with improvements in multiple PSG measures, including the obstructive apnea–hypopnea index (oAHI) and the nadir oxygen saturation.

2. Materials and methods

We identified three non-consecutive children with micrognathia at two tertiary care institutions who had undergone PSG in both the prone and supine positions. We received approval for this study by the institutional review boards at both institutions.

2.1. Polysomnography

Standard overnight 16-channel PSG was performed at the Children's Hospital of The King's Daughters Pediatric Sleep Laboratory (Norfolk, Virginia) for patient 1 and in the Johns Hopkins Pediatric Sleep Laboratory (Baltimore, Maryland) for patients 2 and 3. Each PSG was conducted in accordance with the American Academy of Sleep Medicine (AASM) guidelines [15] and was scored by pediatric sleep medicine specialists. The PSGs included 3 to 6 lead electroencephalogram (EEG), left and right electro-oculograms (EOG), submental electromyogram (EMG), tibial EMG, electrocardiogram (ECG), and oxyhemoglobin saturation. End-tidal CO_2 was obtained in all participants. Airflow was measured with a nasal cannula connected to a differential pressure transducer. Thoracic and abdominal respiratory effort were assessed using inductance pneumography for patient 1 and inductive plethysmography for patients 2 and 3. Body position was monitored via infrared video camera. Information obtained from PSGs included total sleep time, sleep efficiency, time spent in each sleep stage, and oxygen and carbon dioxide levels. Recorded respiratory data included counts and indices of the following events: obstructive apneas, obstructive hypopneas, central apneas (CAs), and mixed apneas.

2.2. PSG Analysis

PSGs were scored according to the AASM guidelines [15]. Apnea was defined as complete absence of airflow for at least two breath cycles. Apneas were identified as obstructive when associated with continued or increased inspiratory effort. They were identified as central when associated with no inspiratory effort. A mixed apnea was identified when absence of airflow was associated with periods with and without inspiratory effort. Hypopnea was defined as a decrease in airflow of $\geq$50% for at least two breath cycles followed by a $\geq$3% decrease in oxygen saturation or an electrocortical arousal from sleep. The apnea–hypopnea index (AHI) was calculated as the number of respiratory events (apneas and hypopneas) divided by the total sleep time. Respiratory event related arousals (RERAs) were not scored by either sleep laboratory. The obstructive apnea–hypopnea index (oAHI) was calculated as the number of obstructive and mixed apneas and hypopneas divided by the total sleep time; CAs were excluded from this calculated value. OSA severity was stratified by AHI. Mild OSA was defined as 1 to <5 events per hour; moderate OSA was defined as 5 to <10 events per hour; and severe OSA was defined as $\geq$10 events per hour.

3. Results

Patient 1 is a white female with Pierre Robin sequence who was discharged from the NICU on continuous pulse oximetry and represented to the emergency department at 7 months (210 days) after multiple cyanotic episodes.

PSG was obtained and showed severe OSA. The parents were offered a tracheostomy and distraction was considered, but these treatments were refused by the parents. Continuous positive airway pressure therapy was trialed during the admission but was not tolerated. The child was eventually discharged on L/min of oxygen and prone position at home. A gastric tube was placed for failure to thrive and oral aversion. At her last visit the child was tolerating oral intake but continued to supplement with gastric tube feeds.

Patient 2 is a white male with Goldenhar syndrome who had significant desaturations and feeding difficulty at birth. He underwent tongue lip adhesion at 2.5 months of age and had improved feeding, with a combination of nasogastric and oral feeding, after surgery. The reported PSG was obtained at 107 days of age. It showed persistent OSA in the supine position, but complete resolution in the prone position, and he was discharged home with prone positioning. At 6 months of age, he was transitioning to oral feeding alone.

Patient 3 is a white male with Pierre Robin sequence who had snoring and witnessed apneas in the first week of life and underwent PSG at 10 days of age. It showed severe OSA that improved to mild OSA, but increased central apneas, in the prone position. In light of desaturations, he was treated with oxygen therapy in the supine position. He was fed with nasogastric tube with increasing oral tastes and ultimately transitioned to oral feeding by 6 months of age.

All 3 children were 7 months of age or younger at the time of the PSG; 2 of 3 had been diagnosed with Pierre-Robin sequence and 1 with Goldenhar syndrome. In the supine position, all three children had severe OSA, with an average oAHI of 21.9 events per hour (Table 1). When moved to a prone position, all 3 exhibited a significant improvement in the oAHI; however, the degree of improvement was variable. Despite improvement, patient 1 continued to have severe OSA; patient 2 had complete resolution of OSA; and patient 3 had mild OSA (Fig. 1A).

With supine positioning, 2 of the 3 children had an oxygen saturation nadir <90%; however, with prone positioning, the oxygen saturation nadir for all three children was >90% (Fig. 1B).

Changes in the CA index were less consistent among the three children. Patient 1 exhibited a significant improvement in this

Table 1
Polysomnography findings in micrognathic children in the prone and supine positions.

Patient	Study duration			Sleep duration (min)	Sleep efficiency (%)	oAHI (events/h)		CAI (events/h)		Saturation nadir (O_2%)		Peak End-tidal CO_2 (mmHg)	
	Total (mins)	Supine (%)	Prone (%)			Supine	Prone	Supine	Prone	Supine	Prone	Supine	Prone
1	510	NR	NR	504	99.0	16.8	10.3	22.5	2.7	87	93	UR	UR
2	436	57	43	316	72.5	22.5	0.3	0.4	0	92	92	>50	<50
3	393	59	41	274	69.7	26.3	4.7	5	12	76	88	61	53

NR = not recorded; UR = unreliable; oAHI = obstructive apnea–hypopnea index; CAI = central apnea index; CO_2 = carbon dioxide.