**Case Report**

**Use of Noninvasive Ventilation with Volume-Assured Pressure Support to Avoid Tracheostomy in Severe Obstructive Sleep Apnea**

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Obstructive sleep apnea (OSA) is a common disorder in children but can occasionally present with life-threatening hypoxemia. Obesity is a significant risk factor for poor outcomes of OSA treatment. Continuous positive airway pressure (CPAP) is indicated in children who are not candidates for or have an unsatisfactory response to adenotonsillectomy. Obese neck, 3+ tonsils, oropharyngeal crowding, hyperactivity, and blunted effect.

In-laboratory polysomnography revealed severe OSA, with AHI 138.2, sleep hypoventilation, and hypoxemia.
Given the severity of his sleep-disordered breathing and morbid obesity, the multidisciplinary pediatric sleep team concluded that the patient was a high-risk candidate for surgery with a very low probability of significant reduction in AHI after adenotonsillectomy. A trial of CPAP was recommended along with weight loss. Both tracheostomy and adenotonsillectomy were planned if these measures failed. During his titration polysomnogram, CPAP via nasal mask was titrated up to 19 cm H2O with only partial reduction of the AHI. Further increases in CPAP pressure were not tolerated.

Despite the pressure intolerance, the patient tolerated the mask well and felt better the following day. Alternative NIV treatment options were considered prior to proceeding with surgery, including VAPS mode with autotitrating expiratory positive airway pressure (EPAP), which has been used successfully in adults with coexisting OSA and hypoventilation syndromes [5]. NIV mode average VAPS with autotitrating EPAP (AVAPS-AE) with nasal mask was initiated in the clinic and continued for a one-week trial at home. He tolerated this well and reported feeling better rested during the home trial. A second titration study was performed one week later to optimize NIV settings. The patient tolerated this well and reported feeling better rested during the home trial. A second titration study was performed one week later to optimize NIV settings. Immediate, substantial reduction of the AHI was achieved with significant improvement in oxygenation, ventilation, and sleep quality (Table 1 and Figure 1(b)).

In follow-up, data download showed good compliance with therapy and control of OSA, with 90% of days used, and average nightly use of 6.4 h without apneas. The father reported that the child was more active and was no longer falling asleep at school. In the clinic, he demonstrated normal mood and was fully awake, calmer, and more interactive. Further interventions focused on weight management, including an admission to an inpatient multidisciplinary weight reduction program, with plans for adenotonsillectomy if significant weight loss was achieved.

### Table 1: Polysomnography parameters at baseline and on CPAP and AVAPS-AE.

| Parameter                                      | Baseline | CPAP titration | AVAPS-AE titration |
|------------------------------------------------|----------|----------------|--------------------|
| Total sleep time (min)                         | 323.5    | 358.0          | 429.0              |
| Sleep efficiency (%)                           | 78.5     | 82.3           | 97.1               |
| Sleep latency (min)                            | 0.5      | 3.0            | 3.0                |
| R latency (min)                                | 175.5    | 238.8          | 132.5              |
| Wake (%)                                       | 88.5 (21.5) | 77.0 (17.7)    | 13.0 (2.9)         |
| N1 (%)                                         | 1.0 (0.2) | 0.0 (0.0)      | 0.0 (0.0)          |
| N2 (%)                                         | 238.5 (57.9) | 175.5 (40.3)  | 268.0 (60.6)       |
| N3 (%)                                         | 63.5 (15.4) | 127.0 (29.2)  | 72.5 (16.4)        |
| R (%)                                          | 20.5 (5.0) | 55.5 (12.8)    | 88.5 (20.0)        |
| Arousals index (arousals/h)                    | 72.3     | 39.7           | 12.3               |
| Periodic limb movement index (events/h)        | 0.0      | 0.0            | 0.0                |
| Apnea-hypopnea index (events/h)                | 138.2    | 57.5           | 9.7                |
| Obstructive apnea index (events/h)             | 122.0    | 44.1           | 0.1                |
| Mean SpO2 (%)                                  | 92       | 94             | 97                 |
| Minimum SpO2 (%)                               | 59       | 72             | 93                 |
| Time SpO2 ≤ 90% (min)                          | 111.7    | 55.9           | 0.0                |
| Baseline ETCO2 (mm Hg)                         | 50       | 36             | 47                 |
| Maximum ETCO2 (mm Hg)                          | 60       | 48             | 51                 |
| Time ETCO2 ≥ 50 (mm Hg) (min)                  | 123.3    | 0.0            | 0.7                |

Note. On diagnostic (baseline) polysomnography, oxygen at 0.25 L/min via nasal cannula was added 40 min after sleep onset due to severe hypoxemia without rebound and maintained for the remainder of the study. CPAP and AVAPS-AE studies were done in room air. AVAPS-AE, average volume-assured pressure support with autotitrating expiratory positive airway pressure; CPAP, continuous positive airway pressure; R, rapid eye movement sleep; N, nonrapid eye movement sleep; SpO2, oxygen saturation by pulse oximetry; ETCO2, end-tidal carbon dioxide.

### 3. Discussion

This report demonstrates the effective use of NIV VAPS to treat OSA refractory to CPAP in a morbidly obese pediatric patient. This is a novel strategy for a child, resulting in a reduction of AHI from very severe (138.2) to moderate levels (9.7) and avoidance of tracheostomy. The child demonstrated good compliance and clinical response.

Although adenotonsillectomy is considered first-line therapy for childhood OSA [1], CPAP and bilevel PAP can be started in selected children with OSA who have not previously undergone adenotonsillectomy [2]. The marked severity of sleep-disordered breathing and coexisting morbid obesity in this patient increased his surgical risk [6], while decreasing the likelihood of benefit. Although studies have shown improvement in AHI in obese children after adenotonsillectomy [2, 7, 8], the prevalence of residual OSA ranged from 33% to 76%, [2] and subsequent weight gain was common [9]. In children with a BMI z-score >2.5, a mean reduction in AHI of only 10 events/h can be expected with adenotonsillectomy alone, while children whose BMI z-score exceeded 3 derived little improvement in AHI [8], suggesting that morbidly obese patients require a more complex approach to treatment than those of normal BMI.
weight [8]. As tracheostomy was considered the next best option to manage this child’s disease, a trial of NIV was attempted with the hope of avoiding this procedure which is also associated with morbidity and reduces quality of life significantly.

Compared to CPAP, AVAPS mode allows the clinician to set variable pressure support that self-adjusts to maintain target tidal volume despite varying respiratory mechanics, ventilatory control, upper airway patency, and respiratory muscle recruitment [10]. It also maintains stable ventilation that can adapt to disease progression in conditions such as neuromuscular disease [11]. Advanced devices add autotitrating EPAP and an automatic back-up rate based on the patient’s spontaneous respiratory rate [10]. Autotitrating EPAP has similar effectiveness to fixed EPAP from an in-laboratory CPAP titration for treating coexisting OSA in adults with hypoventilation syndromes receiving NIV [5].

The use of NIV VAPS is uncommon in children, limited to two case reports in congenital central hypoventilation [12, 13] and one case report in myopathy [14]. This report suggests a novel use of this NIV mode. Our experience suggests that a trial of NIV VAPS with either a fixed or autotitrating EPAP may be considered as a potential treatment option in obese children with severe OSA who fail

**Figure 1:** Baseline polysomnogram demonstrated severe obstructive sleep apnea and hypoxemia (a). There was a significant reduction of obstructive events and normalization of oxygenation during AVAPS-AE titration (b). Both figures shown in 2-minute intervals are of rapid eye movement sleep.
CPAP therapy prior to considering tracheostomy, where appropriate institutional and family support are available.

**Conflicts of Interest**

The authors declare that they have no conflicts of interest.

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