CASE REPORT

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Non-invasive home ventilation using the average volume assured pressure support feature in an infant with severe bronchopulmonary dysplasia and chronic respiratory failure

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ABSTRACT

Introduction: While majority of infants with bronchopulmonary dysplasia (BPD) can be discharged home without low flow oxygen or on supplemental low flow oxygen, some require long term home mechanical ventilation.

Case presentation: We present a case of an extremely premature infant with severe bronchopulmonary dysplasia who was successfully managed at home on a new feature of non-invasive ventilation called average volume assured pressure support (AVAPS) without the need for tracheostomy. The AVAPS feature enables the machine to deliver a consistent tidal volume by automatically adjusting the inspiratory pressure within a set range.

Conclusion: The use of AVAPS feature in our case improved ventilation as indicated by a more stable gas exchange profile, making home non-invasive ventilation a more practicable method of managing severe BPD in this infant.

KEYWORDS

Bronchopulmonary dysplasia, Home ventilation, Infant, Average volume assured pressure support (AVAPS)

INTRODUCTION

Advances in perinatal care have reduced mortality rates for pre term infants but this has not led to a proportionate reduction in certain neonatal morbidities. Despite steady improvements in the area of neonatal respiratory support, bronchopulmonary dysplasia (BPD) remains the most common neonatal morbidity in extremely premature infants. Respiratory outcomes range from no respiratory support to chronic ventilator dependency for those with severe BPD. An increasing number of children with severe BPD and chronic respiratory failure are receiving home mechanical ventilation through tracheostomy.[1] Tracheostomy provides a secure airway but carries significant morbidity and mortality risk. With the dramatic changes in technology that supports home ventilators, increasing options are now available to manage these infants at home through non-invasive ventilation (NIV). We present the case of an extremely premature infant in chronic respiratory failure who was successfully managed at home, non-invasively, using the newer average volume assured pressure support (AVAPS) feature thereby avoiding a tracheostomy, improving gas exchange and significantly reducing length of stay in the hospital.

CASE REPORT

Our case is an extreme preterm infant born at 24 weeks gestation with a birth weight of 678 grams. Soon after birth, he developed respiratory distress and was intubated and ventilated. A total of 2 courses of surfactant were administered. He needed intubation and ventilation

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for first 4 weeks of life followed by nasal continuous positive airway pressure (CPAP) for 11 weeks, high flow respiratory support for 4 weeks followed by use of low flow supplemental oxygen. He developed significant hypercarbia on low flow oxygen, requiring re-intubation on day 117 of life; followed by a step down in respiratory support to CPAP and then low flow oxygen. Transthoracic cardiac echocardiography showed a structurally normal heart with no evidence of pulmonary hypertension. He received two courses of post-natal steroids on day 16 and 26 for extubation to CPAP. He received caffeine for prevention of apnoea of prematurity till day 137 of life. Diuretics were administered to try and improve respiratory status. Chest radiograph was in keeping with severe BPD.

The infant was transferred to our tertiary centre for management of respiratory failure. His daytime partial pressure of CO_2 (PCO_2) on capillary blood gas fluctuated between 126 and 70 mmHg on low flow oxygen. His capillary blood gas on low flow oxygen continued to show compensated respiratory acidosis with pH 7.37, PCO_2 70 mmHg, partial pressure of O_2 (PO_2) 40.2 mmHg and HCO_3 39.3 mmol/L. To improve hypercarbia, use of bi-level positive airway pressure (BPAP) instead of low flow oxygen was planned. A sleep study was organised to better study ventilation and gas exchange. Desensitisation to BPAP mask was commenced prior to BPAP initiation. The sleep study was commenced on low flow oxygen but due to hypercarbia (transcutaneous CO_2 [$TcCO_2$]-100 mmHg), conventional nasal mask BPAP was commenced. There was improvement in $TcCO_2$ (ranging from 62–73 mmHg) on nasal BPAP. To maintain adequate oxygenation, 2 L oxygen was added through BPAP circuit. In view of ongoing hypercarbia, AVAPS feature on BPAP using Trilogy 100 (Philips, Murrysville, PA, USA) was trailed. There was significant improvement in hypercarbia on the AVAPS feature; $TcCO_2$ ranging from (40–50 mmHg) (Figure 1). There was also a reduction in need for supplemental oxygen down to 600 mL from 2 L through the BPAP circuit. The final settings on AVAPS were: IPAP max 20 cmH_2O, IPAP min 12 cmH_2O, EPAP 5 cmH_2O, Inspiratory time 0.5 sec, back up rate 30/min, tidal volume 60 mL (approximate 10 mL/kg) on PC mode.

DISCUSSION

This report demonstrates the effective use of the AVAPS feature to treat an extremely premature infant with severe BPD in chronic respiratory failure. The use of AVAPS feature resulted in improvement of hypercarbia and gas exchange, avoidance of tracheostomy and early discharge to home from the hospital. In many centres around the world, children with severe BPD receive long term ventilatory support through tracheostomy.[2-4] A large single centre study reported that most children with severe BPD were liberated of positive pressure ventilation before their fifth birthday. However, only 58% of these children were able to be successfully decannulated in the following year.[1] Although the benefits of tracheostomy outweigh the associated risks in cases with an unprotected airway, some children with severe BPD needing ventilation such as our case, may be managed at home without needing a tracheostomy.

The AVAPS feature enables the machine to automatically adjust the inspiratory pressures to deliver a constant targeted tidal volume. Tidal volumes as low as 50 mL can be set and reliably delivered with the AVAPS feature. This feature enabled a better control of ventilation in our case as indicated by a more stable transcutaneous carbon dioxide profile and a reduction in supplemental oxygen as compared to conventional nasal non-invasive BPAP.

Use of non-invasive BPAP in young neonates has its own challenges. The challenges such as in our case include, finding appropriate interface, ensuring proper parental education and prevention of mid-facial hypoplasia from mask use. In our case, a mask specifically designed for neonates and infants was used, parents were provided intensive inpatient education on use of BPAP and a regular follow up was planned in our airway support clinic to monitor for complications arising from BPAP use. The infant was treated with NIV continuously and demonstrated excellent adherence to treatment. Over a period of several months, NIV was slowly weaned with close monitoring of clinical and growth parameters. Supplemental oxygen was used during the periods he was off NIV support. The infant continues to thrive and reach age appropriate milestones. As the infant demonstrated stable gas exchange over the prolonged inpatient stay, we did not use a home oximeter for monitoring at discharge. Parents were instructed to present to the nearest emergency department should they have any concerns about his breathing. In our case, the Trilogy 100 (Philips, Murrysville, Pa.) device was funded through the state government supported EnableNSW services.

Use of AVAPS in children is limited to case reports.[5,6] A previous case report successfully used AVAPS feature in a 10 month old child with congenital central hypoventilation syndrome to achieve effective non-invasive ventilation.[7] The minimum tidal volume threshold of 50 mL and high trigger sensitivity limits the use of AVAPS in younger infants. Data from randomized control trial or large case series in children on the use of AVAPS feature are lacking. Long term follow up data on the use of AVAPS feature in children are needed.

In summary, to our knowledge, this is the first case report of successful use of home BPAP with AVAPS feature in an extremely premature infant with BPD and chronic respiratory failure. Large prospective studies are needed to confirm the efficacy and safety of the AVAPS feature in this population.

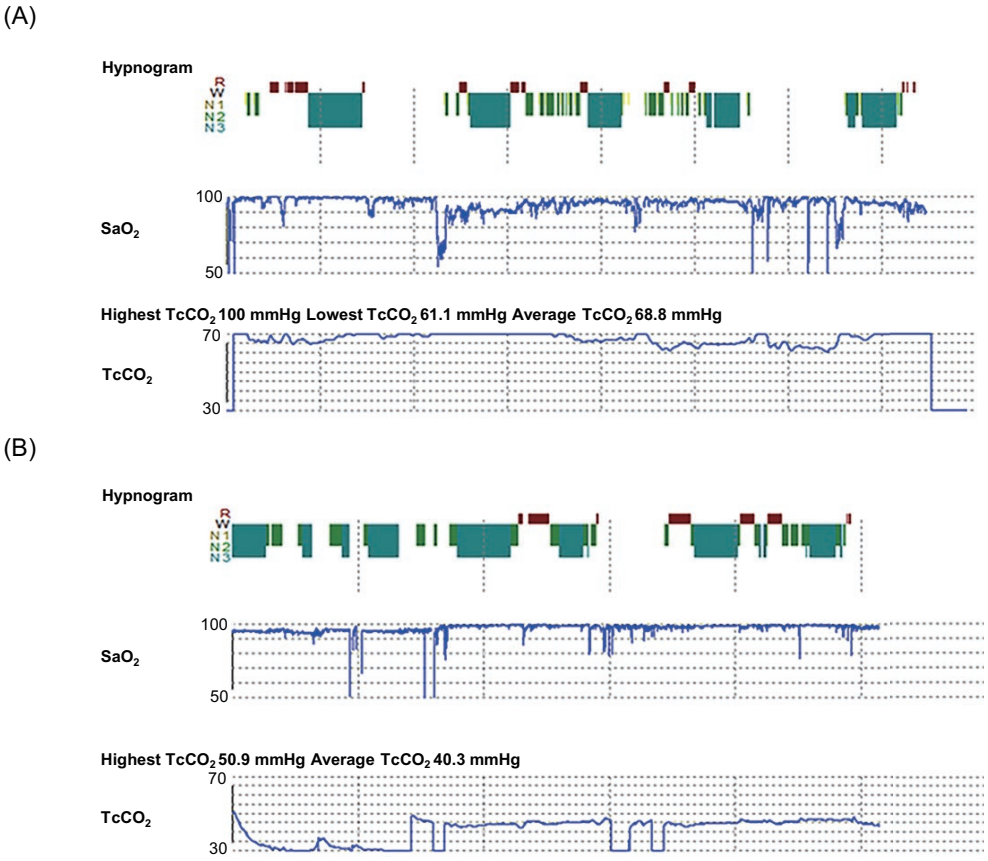

FIGURE 1 Hypnogram with oxygen saturation and transcutaneous carbon dioxide ($TcCO_2$) on split study (low flow oxygen and conventional bi-level positive airway pressure [BPAP]) and average volume assured pressure support (AVAPS) titration study. (A) Study was commenced on low flow oxygen and changed to conventional BPAP with 2 L/min of supplemental oxygen through the BPAP circuit after the first REM sleep. Note disrupted sleep with high $TcCO_2$ and frequent oxygen desaturation. (B) $TcCO_2$ trace on polysomnography using AVAPS. Note improvement in $TcCO_2$, oxygen saturation and sleep efficiency.

CONSENT FOR PUBLICATION

Appropriate written informed consent was obtained for publication of this case report and accompanying images.

CONFLICT OF INTEREST

We have no conflict of interest to report.

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