

Average volume-assured pressure support

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ABSTRACT

Average volume-assured pressure support (AVAPS) is a relatively new mode of non-invasive positive pressure ventilation (NiPPV); only a few studies have been done to compare its effectiveness and safety to bilevel positive airway pressure (BiPAP) in chronic respiratory failure secondary to obesity hypoventilation syndrome, obstructive sleep apnea, chronic obstructive pulmonary disease, and neuromuscular disorders with respiratory muscle weakness. Only six studies were found in PubMed, and these studies had many limitations, especially small sample sizes. This review provides detailed summaries of these studies. These devices require more investigation.

Keywords: non-invasive ventilation, pressure support, average volume-assured pressure support, obesity-hypoventilation syndrome, COPD, hypercapnia

BACKGROUND

Average volume-assured pressure support (AVAPS) and intelligent VAPS (iVAPS) are forms of non-invasive positive pressure ventilation (NiPPV) that adjust the pressure support (PS) to maintain a target average ventilation over several breaths. Both AVAPS and iVAPS adjust PS and the respiratory rate to reach a defined target with the goal of stabilizing the PaCO₂, which relates directly to alveolar ventilation.¹

With a target tidal volume (e.g., AVAPS), if there is a variance in the respiratory mechanics, especially compliance, which in turn can change the tidal volume, there can be fluctuations in the alveolar ventilation and thus PaCO₂. By targeting the estimated alveolar ventilation (minute ventilation–estimated dead space ventilation; e.g., iVAPS), variations in respiratory mechanics should not affect alveolar ventilation or PaCO₂ as long as the estimated dead space

equals physiologic dead space. The device estimates the anatomic dead space using height. However, patients with lung diseases, such as emphysema, have increased physiologic dead space that would be underestimated using their height, and thus their alveolar ventilation might be much lower than the estimated alveolar ventilation. Thus, emphysema patients may require a higher target alveolar ventilation to achieve adequate alveolar ventilation. The “height” can be entered artificially high in emphysema patients to provide a calculated dead space closer to their physiologic dead space, and iVAPS will provide the desired alveolar ventilation.

Average volume-assured pressure support targets an average tidal volume over several breaths. Typically, the target tidal volume is set based on 6–10 mL/kg ideal body weight. It calculates the average PS provided to the patient over the prior 2 minutes to achieve a particular tidal volume. If average recent ventilation is less than the target volume, inspiratory positive airway pressure (IPAP) for the next breath is increased. Pressure support will change at a rate of 2 cm H₂O/minute if there is unstable breathing and 1 cm H₂O/minute if there is stable breathing. The AVAPS-AE model can set

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a maximum rate of pressure change from 1 cm H₂O/minute to 5 cm H₂O/minute. Expiratory positive airway pressure (EPAP) is fixed with AVAPS, but AVAPS-AE adjusts EPAP as well. Average volume-assured pressure support uses either a fixed rate or auto backup rate set at 2 breaths per minute lower than the rate of the last six spontaneous breaths.

This mode of ventilation can help patients with respiratory insufficiency due to neuromuscular and restrictive disorders in which the respiratory effort varies during sleep,² patients who need NiPPV during the day, patients with COPD at risk for hypoventilation, and patients with obesity hypoventilation (OHS) who may need compensation based on position and/or sleep stage changes. Because many patients have much worse hypoventilation in REM, BiPAP with fixed PS may provide too much pressure in NREM, which may lead to intolerance or complex sleep apnea and may not provide enough PS in REM to control PaCO₂ levels.

The theoretical benefits of VAPS over BiPAP include maintaining volumes in the setting of altered patient effort based on sleep stage or altered lung mechanics related to position. Less PS while awake may increase comfort and aid sleep onset, reduce the risk of barotrauma, and provide lower pressures most of the time. A randomized trial of iVAPS vs BiPAP found that iVAPS delivered a lower mean PS for oxygenation and transcutaneous PaCO₂ levels and promoted better adherence than BiPAP.³

This literature review provides a detailed summary of studies with AVAPS in patients with chronic respiratory failure, OHS, and COPD with acute hypercapnic exacerbations (also see Table).

Study # 1-Sleep and non-invasive ventilation in patients with chronic respiratory insufficiency²

Study goals

- This study tests the hypothesis that AVAPS and the lateral decubitus position in patients with chronic respiratory insufficiency are associated with better sleep efficiency than NIV- PS and the supine position. The secondary aim of the study was to assess the effect of the mode of ventilation, body

position, and sleep-wakefulness state on minute ventilation in the same patients.

Methods

- A single blind, randomized, cross-over, prospective trial studied the effects of NIV-PS vs AVAPS on sleep efficiency in twenty-eight patients with chronic respiratory insufficiency (OHS with or without OSA, COPD, neuromuscular disease).
- Thirty-nine patients with the diagnosis of chronic respiratory insufficiency who were currently receiving home ventilation (NIV-PS) for at least two months and were adherent to this therapy (4 hours per night) were recruited. Exclusion criteria included hemodynamic instability, a history of CHF or Cheyne Stokes respiration, inability to clear secretions, and acute sinusitis, otitis media, facial trauma, or other anatomical abnormalities interfering with mask fit. The study was conducted in a hospital ward.
- Each subject underwent three consecutive overnight sleep studies: 1) Conventional NIV-PS set at the patients' prescription settings to validate the prescription pressures and to serve as an acclimatization night, 2) AVAPS or NIV therapy assigned randomly, and 3) cross-over to alternate therapy mode. Patients underwent randomization only if their prescription pressure did not change significantly (>5 cm H₂O) during the first sleep study. Eleven patients were excluded (central apneas, n = 3; pressure change >5 cm H₂O, n = 6; refractory hypoxemia, n = 1; inadequate sleep, n = 1).

Results

- Twenty-eight patients had adequate pressure settings and received BiPAP or AVAPS on separate nights. The IPAP level during BiPAP remained fixed at 17 ± 4 cm H₂O. During AVAPS therapy, the set IPAP_{min} and IPAP_{max} were 13 ± 4 and 26 ± 3 cm H₂O, respectively. During AVAPS therapy, the mean IPAP pressure was 18 ± 5 cm H₂O which tended to be higher than IPAP during BiPAP (17 ± 4 cm H₂O; P = 0.08; paired t test), and the IPAP during AVAPS therapy fluctuated between a low of 14 ± 6 cm H₂O and a high of 21 ± 5 cm H₂O.

Author Study goal	Design	Study subjects	Results	Conclusions	Limitations*
Ambrogio ² To study the effects of NIV-PS vs AVAPS on sleep efficiency in patients with chronic respiratory insufficiency	Single-blind, randomized, cross-over, prospective trial	28 patients with CRF (OHS/O SA, COPD, NMD) who were currently receiving home ventilation (BiPAP) for at least 2 months and adherent to such therapy (4 h per night)	Neither BiPAP nor AVAPS significantly modified sleep architecture, quality, or quantity.	In patients with CRF, AVAPS was comparable to BiPAP therapy with regard to sleep, but increased the minute ventilation. Significance was uncertain.	The higher Vt in the AVAPS group might reflect a poor choice of fixed PS in the BiPAP group. The difficulty of matching disease type and severity since the inclusion criteria were so broad.
Storre ³ To study the physiological and clinical effects of AVAPS in OHS patients who did not respond to therapy with CPAP.	Prospective randomized crossover trial	10 patients age 53.5 ± 11.7 years; BMI 41.6 ± 12.1 kg/m ² ; transcutaneous PCO ₂ 58 ± 12 mmHg	Sleep quality & gas exchange improved during BPV-S/T therapy, but patients remained hypercapnic overnight. The addition of AVAPS to BPV-S/T significantly decreased PaCO ₂ , but it did not improve sleep quality.	BPV-S/T substantially improved oxygenation, sleep quality, and HRQL in patients with OHS. AVAPS provided additional benefits on ventilation quality, thus resulting in a decrease of PaCO ₂ . However, this did not provide further improvement in sleep quality.	The higher tidal volume in the AVAPS group might reflect a poor choice of the IPAP setting in the BiPAP group.
Crisafulli ⁴ To evaluate night-time efficacy, compliance, & physiological responses to AVAPS versus PS ventilation.	Single-blind, randomized, crossover study	Nine stable hypercapnic COPD patients were prescribed AVAPS or PS ventilation by mask over two 5-day periods during consecutive weeks.	Measurements were similar between the two treatment periods at baseline. PaCO ₂ and comfort improved with both modalities; the SE score significantly improved with AVAPS.	No difference in mean usage was found between the two modalities. AVAPS is as comfortable and effective as PS at reducing respiratory acidosis but produces better perceived SE in stable hypercapnic COPD patients.	

Author Study goal	Design	Study subjects	Results	Conclusions	Limitations*
Murphy ⁵ Does the addition of volume-targeted (NIV) to standard fixed bi-level pressure support (PS) improve physiological and clinical outcomes in the treatment of stable obesity hypoventilation syndrome?	Patients with OHS were enrolled in a two-center prospective single-blind randomized controlled trial of AVAPS versus fixed-level PS using a strict protocolized setup.	50 patients (BMI 50 ± 7 kg/m ² ; age 55 ± 11 years; 53% men; mean PaCO ₂ of 52 mmHg, SRI of 53 ± 17) were enrolled. 46 patients (23 AVAPS and 23 PS) completed the trial.	At 3 months, improvements in PaCO ₂ & SRI score were observed in both groups. Secondary analysis of both groups combined showed improvements in daytime physical activity and a reduction in fat mass.	The study demonstrated no differences between AVAPS and fixed-level PS modes using a strict protocolized setup in patients who were super obese. The data suggest that the management of sleep-disordered breathing may enhance daytime activity and promote weight loss in super-obese patients.	
Briones ⁶ To assess the use of AVAPS in patients with COPD exacerbation and hypercapnic encephalopathy as compared to BiPAP S/T alone, upon immediate arrival in the Emergency-ICU.	Prospective interventional match-controlled study that was done in Ecuador.	22 patients, 11 with COPD exacerbations & hypercapnic encephalopathy (GCS <10 and a pH of 7.25-7.35) managed with AVAPS. 11 patients selected as paired controls and managed with BiPAP S/T.	There was a statistically significant differences in favor of the AVAPS group in GCS. However, no significant differences in length of stay or days on NIV were observed.	AVAPS facilitates rapid recovery of consciousness when compared to traditional BiPAP S/T in patients with acute COPD exacerbation and hypercapnic encephalopathy.	The differences between AVAPS and BiPAP could reflect a poor choice in BiPAP parameters.
Piesiak ⁷ Evaluation of the effectiveness of AVAPS in patients with kyphoscoliotic chronic respiratory failure.	12 patients (age 49 ± 11 yr, BMI 27.5 ± 7.9) with advanced kyphoscoliosis complicated by severe respiratory failure	The patients were treated by AVAPS, and the efficacy of AVAPS was evaluated, short-term, after 5 days, and long-term, after 1 year of home treatment.	Significant improvement of diurnal PaO ₂ and PaCO ₂ on the 5th day of AVAPS and FVC increased after 1 year. NIMV was well tolerated.	AVAPS improved gas exchange and forced vital capacity in patient with CRF due to kyphoscoliosis	

* All studies have a small sample size and difficulty with blinding patients to treatment modality.
 BMI-body mass index; CRF-chronic respiratory failure; yr-year; PS-pressure support
 AVAPS-average volume assured pressure support; BiPAP-bilevel positive airway pressure; NIMV-non-invasive mechanical ventilation; GCS-Glasgow coma scale; OSA-obstructive sleep apnea, OHS-obesity hypoventilation syndrome; COPD-chronic obstructive pulmonary disease, Vt-tidal volume, NMD-neuromuscular disease, SE-sleep efficiency, SRI-severe respiratory insufficiency.

- Sleep architecture was similar in both modes. However, the supine body position was associated with decreased sleep efficiency when compared to the lateral decubitus position ($77.9 \pm 22.9\%$ and $85.2 \pm 10.5\%$; $P = 0.04$). The apnea-hypopnea index was greater during the supine position (median 6.3) than during lateral position (median 0.6).
- Minute ventilation decreased progressively from wakefulness through various stages of sleep (stage 1, stage 2, and REM, $P = 0.0001$) during BiPAP therapy in the supine position. During BiPAP therapy in the lateral decubitus position, minute ventilation decreased progressively from wakefulness through various stages of sleep (stage 1, stage 2, and REM, $P = 0.018$). During AVAPS in the supine position, the minute ventilation did not change from wakefulness through the various stages of sleep.

Conclusions

- In patients with chronic respiratory insufficiency, the supine position was associated with worse sleep efficiency than the lateral decubitus position. Average volume-assured pressure support was comparable to BiPAP therapy with regards to sleep, but a statistically greater minute ventilation during AVAPS than BiPAP was observed. Minute ventilation was determined by sleep-wakefulness state, body mass index (BMI), and mode of therapy, but not by body position. Changes in minute ventilation during BiPAP therapy were independent of effects of body position and BMI, were due primarily to decreases in tidal volume rather than in respiratory rate, and were less likely during AVAPS.

Study # 2-Average volume-assured pressure support in obesity hypoventilation³

Study Goals

- This small prospective randomized crossover trial studied the physiological and clinical effects of AVAPS in 10 OHS patients who did not respond to CPAP. The effects of bilevel pressure ventilation with the spontaneous /timed (BPV with S/T) mode with and without AVAPS over 6 weeks on ventilation pattern, gas exchange, sleep quality, and health related

quality of life (HRQL) assessed by severe respiratory insufficiency questionnaire (SRI) were prospectively investigated in a randomized crossover trial.

Methods

- Inclusion criteria: Clinically stable OHS patients with a body mass index of 30 kg/m^2 and daytime hypercapnia ($\text{PaCO}_2 >45 \text{ mm Hg}$) who had failed to respond to CPAP therapy, had no other cause for their chronic respiratory failure, and were naive to any ventilatory treatment. Exclusion criteria: Patients who had evidence of acute respiratory failure (patients with worsening symptoms during the last 2 weeks, a breathing frequency of 30 breaths/minute, a $\text{pH} < 7.35$, or signs of respiratory infections). Patients who had been intubated during the last 3 months or had received any other form of ventilatory support prior to hospital admission were also excluded from the study. A CPAP responder was defined as a patient who achieved a transcutaneous PaCO_2 level of $<45 \text{ mm Hg}$ and a respiratory disturbance index (RDI) score of <10 events per hour.
- CPAP nonresponders were discharged from the hospital to home with therapy with BPV-S/T with or without AVAPS following randomization and were readmitted to the hospital after 6 weeks of home therapy. Baseline measurements were repeated, and patients were switched to the alternate mode of BPV-S/T. Measurements were again performed after another period of 6 weeks home therapy following hospital readmission.
- Measurements: pulmonary function tests, daytime blood gas at rest, HRQL measured using the RSI questionnaire, polysomnography, and PtcCO_2 measured during the night at baseline, and during therapy with CPAP, BPV-S/T, and BPV-S/T-AVAPS. Measurements of ventilation were made during therapy with both modes of BPV-S/T using a pneumotachograph to measure volumes, pressures, and respiratory rate.

Results

- Ten patients (mean \pm SD; age 53.5 ± 11.7 years; BMI $41.6 \pm 12.1 \text{ kg/m}^2$; FEV1/FVC ratio, $79.4 \pm 6.5\%$)

predicted; transcutaneous PCO_2 58 ± 12 mm Hg; IPAP for BPV 17 ± 2 cm H_2O ; tidal volume for AVAPS 7 ml/kg [five patients] and 10 ml/kg [five patients]) completed the study. PtcCO_2 non-significantly decreased during nocturnal BPV-S/T by -5.6 ± 11.8 mm Hg (95% confidence interval [CI], -14.7 to 3.4 mm Hg; $p=0.188$), but significantly decreased during AVAPS by -12.6 ± 12.2 mm Hg (95% CI, -22.0 to -3.2 mm Hg; $p=0.015$). Pneumotachographic measurements revealed a higher individual variance of peak inspiratory pressure ($p < 0.001$) and a trend for lower leak volumes and for higher tidal volumes during AVAPS. Sleep quality and oxygen saturation also comparably improved using both BPV-S/T and AVAPS.

- Sleep quality and gas exchange substantially improved during nocturnal BPV-S/T therapy compared to baseline, but patients remained hypercapnic overnight even after 6 weeks of BPV-S/T therapy. The addition of AVAPS to BPV-S/T therapy resulted in a significant decrease of PaCO_2 and normalized PaCO_2 during sleep. However, this reduction in PaCO_2 did not lead to further improvements in sleep quality compared to standard BPV-S/T therapy. Daytime PaCO_2 and bicarbonate levels significantly improved following AVAPS therapy only.

Conclusions

- The BPV-S/T mode substantially improved oxygenation, sleep quality, and HRQL in patients with OHS. Average volume-assured pressure support provided additional benefits on ventilation quality and resulted in a bigger decrease in PaCO_2 . However, this did not provide further clinical benefits in sleep quality and HRQL.

Study # 3-Subjective sleep quality during AVAPS ventilation in patients with hypercapnic COPD: a physiological pilot study⁴

Study Goals

- This single-blind (ventilator modalities were blinded to the patients), randomized, crossover study evaluated night-time efficacy, compliance,

and physiological responses to AVAPS versus PS ventilation.

Methods

- Average volume-assured pressure support or PS ventilation was delivered to nine stable hypercapnic COPD patients by a mask over two 5-day periods during consecutive weeks. The Synchrony ventilator was used to deliver mask ventilation as follows: 8 ml/kg of ideal body weight (as the targeted inspiratory tidal volume) with IPAP ranging from EPAP up to 30 cm H_2O for AVAPS, and the patient's highest tolerated IPAP level for PS. Expiratory positive airway pressure was set at the minimum level for both modalities and oxygen was added at a fixed inspiratory fraction to maintain SaO_2 above 90%.
- Inclusion criteria: stable chronic hypercapnia at rest without respiratory acidosis $\text{PaCO}_2 > 45$ mmHg, $\text{pH} > 7.35$, severe COPD (stage III or IV) according to GOLD classification, naive to NPPV, and apnea/hypopnea index (AHI) < 10 episodes/hour as assessed by preliminary polysomnography. Exclusion criteria: patients with unstable hemodynamic and respiratory conditions (e.g., recent acute heart failure, respiratory exacerbation or infection with worsening symptoms during the preceding four weeks, and/or changes in any domiciliary therapy in the last week), malignancies, or an inability to cooperate.
- Measurements: Demographic and anthropometric variables (age, sex, BMI) and lung function parameters (FEV_1 , FVC, FEV_1/FVC , RV, TLC), voluntary respiratory muscle strength values (MIP and MEP). Compliance to ventilation, as measured by mean usage (hours/night), arterial blood gases, comfort, and perceived sleep efficiency (SE by questionnaire) were measured at baseline (T0) and after three (T1) and five (T2) nights over the two periods.

Results

- Measurements were similar between the two treatment periods at baseline. PaCO_2 and comfort improved with both modalities; the SE score significantly improved at T2 with AVAPS (from

5.1 ± 2.0 to 4.1 ± 2.2 , $P = 0.001$) but not with PS (from 5.1 ± 1.7 to 4.7 ± 1.3 , $P = 0.219$).

Conclusions

- No difference in mean usage was found between the two modalities. Mask AVAPS was as comfortable and effective as PS at reducing respiratory acidosis but produced better perceived sleep efficiency in stable hypercapnic COPD patients.

Study # 4-Volume targeted versus pressure support non-invasive ventilation in patients with “super” obesity and chronic respiratory failure: a randomized controlled trial⁵

Study Goals

- A prospective single-blind randomized controlled trial of AVAPS versus fixed-level PS using a strict protocol done in two centers investigated the effects of the addition of AVAPS to standard BiPAP on the physiological and clinical outcomes in the treatment of stable OHS.

Methods

- Inclusion criteria: BMI >40 kg/m²; daytime stable respiratory failure with PaCO₂ >45 mmHg and pH >7.35 ; absence of another identifiable cause of hypoventilation; FEV₁/FVC >0.70 ; and FVC $<70\%$ predicted. Exclusion criterion: an inability to provide written informed consent.
- 50 patients (BMI 50 ± 7 ; age 55 ± 11 years; 53% men, with a mean PaCO₂ of 51.8 mmHg and SRI of 53 ± 17) were enrolled in the study. Patients were randomly allocated to either fixed bi-level PS or AVAPS mode. Both modes were delivered by a BiPAP synchrony device. Pre-randomization minimization was performed to avoid allocation bias; variables were BMI (40-50, 50-60, and >60), neck circumference (<45 cm and >45 cm), gender, and clinical presentation (acute or elective).
- Measurements: Baseline spirometry, arterial blood gases, anthropometrics including body composition measurements, HRQL assessed by severe

respiratory insufficiency questionnaire (SRI), and self-reported sleep comfort. Following randomization, patients underwent respiratory polygraphy, including oximetry and measurement of tcPCO₂, and supplemental oxygen was provided to patients who met the criteria for daytime hypoxemia. Once established on NIV, patients were discharged and followed up at 3 months.

- The primary outcome was change in daytime arterial PaCO₂ at 3 months. Body composition, physical activity, and HRQL (severe respiratory insufficiency questionnaire, SRI) were secondary outcome measures.

Results

- 46 patients (23 AVAPS and 23 PS) completed the trial. At 3 months, improvements in PaCO₂ occurred in both groups (AVAPS Δ 4.5 mmHg, 95% CI 1.5 to 8.25, $p < 0.01$ vs PS Δ 4.5 mmHg, 95% CI 0.75 to 8.25, $p = 0.02$) but no between group difference (Δ $-0.7.5$ mmHg, 95% CI 5.25 to 4, $p = 0.87$). The SRI improved in both groups (AVAPS Δ 11, 95% CI 6 to 17, $p < 0.001$ vs PS Δ 7, 95% CI 1 to 12, $p = 0.02$; between groups Δ 5, 95% CI -3 to 12, $p = 0.21$). Secondary analysis of both groups combined showed improvements in daytime physical activity that correlated with reductions in fat mass.

Conclusions

- The study demonstrated no differences between automated AVAPS mode and fixed-level PS mode using a strict protocol setup in patients who were “super” obese. The data suggest that the management of sleep-disordered breathing may enhance daytime activity and promote weight loss in “super” obese patients.

Study # 5-Noninvasive mechanical ventilation with AVAPS in patients with COPD and hypercapnic encephalopathy⁶

Study Goals

- This study assessed the use of AVAPS in patients with COPD exacerbation and hypercapnic encephalopathy compared to BiPAP S/T

alone upon immediate arrival to the Emergency Department or the ICU.

Methods

- This was a prospective interventional match-controlled study with 22 patients. Eleven patients with COPD exacerbations and hypercapnic encephalopathy with a Glasgow Coma Scale (GCS) <10 and a pH of 7.25-7.35 were assigned to receive AVAPS. Eleven patients were selected as paired controls for the initial group by physicians who were unfamiliar with the study, and these patients were managed with BiPAP S/T. Arterial blood gases, GCS, vital signs, and ventilatory parameters were then measured and compared between the two groups.

Results

- There was a statistically significant difference in favor of the AVAPS group in GCS ($P = .00001$), PaCO_2 ($P = .03$) and maximum IPAP ($P = .005$). However, no significant differences in length of stay or days on NIV were observed.

Conclusions

- Average volume-assured pressure support facilitates rapid recovery of consciousness when compared to traditional BiPAP S/T in patients with acute COPD exacerbation and hypercapnic encephalopathy. Average volume-assured pressure support is also a safe strategy of noninvasive ventilatory treatment in patients with exacerbations of COPD and hypercapnic encephalopathy (GCS < 10), with the caveat that these patients should be treated in units with ample experience and under close surveillance.

Study # 6-Efficacy of AVAPS in patients with chronic respiratory failure due to kyphoscoliosis⁷

Study Goals

- This study evaluated the effectiveness of AVAPS in patients with kyphoscoliosis and chronic respiratory failure.

Methods

- The study included 12 patients (mean age 49 ± 11 years and body mass index 27.5 ± 7.9 kg/m²) with advanced kyphoscoliosis complicated by severe respiratory failure (PaCO_2 650.1 ± 2.6 mmHg, SaO_2 81.7 ± 3.1 %, PaCO_2 71.3 ± 8.1 mmHg) treated by AVAPS. The short-term after 5 days and long-term after 1 year of home treatment efficacy of AVAPS was evaluated.

Results

- The study found a significant improvement of diurnal PaO_2 and PaCO_2 on the 5th day of AVAPS (an increase of 10.4 ± 2.3 mmHg and a decrease of 13.5 ± 6.0 mmHg, respectively; $p < 0.05$) and after one year AVAPS (an increase of 15.5 ± 3.5 mmHg and a decrease of 20.1 ± 6.5 mmHg, respectively; $p < 0.05$). There was a significant increase of mean blood oxygen saturation during sleep on the 5th day (86.2 ± 3.2 %) and after 1 year of treatment (89.4 ± 2.1 %) compared with the baseline level (83.2 ± 3.2 %). The forced vital capacity also increased after 1 year ($1,024 \pm 258$ ml vs. the baseline 908 ± 267 ml; $p < 0.05$). Average volume-assured pressure support was well tolerated, and no patient discontinued the treatment during the observation period.

Conclusions

- Average volume-assured pressure support decreased the PaCO_2 and increased the PaO_2 and FVC in patients with kyphoscoliosis and chronic respiratory failure.

SUMMARY

These six studies included 127 patients who were managed with either AVAPS or BiPAP or both modes of non-invasive ventilation (See Table for summary of study results).

For **Outpatient management**: There was no difference between the two modalities in improving sleeping efficiency and HRQL in patients with chronic

respiratory insufficiency due to OHS with or without OSA, COPD, and neuromuscular disease. There was no difference in mean usage between the two modalities. Mask AVAPS was as comfortable and as effective as PS at reducing respiratory acidosis in stable hypercapnic COPD patients. There were no differences between using AVAPS and fixed-level PS mode in patients who were “super” obese. AVAPS provided additional benefits on ventilation quality, thus resulting in a more efficient decrease of PaCO₂. However, this did not provide further clinical benefits in sleep quality and HRQL, and this result has uncertain significance.

For **Inpatient management**: In patients with acute COPD exacerbation and hypercapnic encephalopathy, AVAPS facilitates rapid improvement in the level of consciousness when compared to traditional BiPAP S/T. However, no significant differences in length of stay or days on NIV were observed. AVAPS is a safe strategy of noninvasive ventilatory treatment in patients with exacerbations of COPD and hypercapnic encephalopathy (GCS < 10). These studies do not identify a clinical scenario in which AVAPS has a definite advantage when compared to bi-level pressure support. Patients managed with non-invasive mechanical ventilation need careful monitoring with defined clinical goals to improve outcomes. The exact mode may be less important.

Criticisms common to all these studies include the small sample size and the difficulty with blinding patients to the treatment modality. The higher tidal volumes in the AVAPS groups may not reflect an advantage of AVAPS but rather a poor choice of fixed pressure support in the BiPAP group.

RECOMMENDATIONS

1. For Outpatient management: AVAPS is as safe and as effective as BiPAP but is not superior to it in the management of outpatients with chronic respiratory insufficiency due to OHS with or without OSA, COPD, and neuromuscular disease.

2. For Inpatient management: AVAPS might be preferred over BiPAP for patients with acute COPD exacerbation and hypercapnic encephalopathy as it facilitates more rapid improvement in the level of consciousness.

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