Adaptive Pressure Support Servoventilation: A New Spin on the Treatment of Heart Failure Patients with Central Sleep Apnea

A recent update from the American Heart Association estimates there are almost five million people with heart failure.[1] Epidemiological studies show that its prevalence will continue to increase because of increased lifespan, aging of the population and continued advances in the treatment of heart disease and hypertension.[1,2] The morbidity, mortality, and the economic burden of heart failure are high.[1,2] In 2002, one million patients were discharged from the hospital with a primary diagnosis of heart failure.[1] Heart failure is a malignant condition with a mortality of 35% at 41 months in the enalapril-treated patients in the SOLVD study,[3] with similar results reported in other trials.[4,5] Although the mechanism is not understood,[6] observations from many sleep laboratories show that a large number of patients with heart failure have sleep-disordered breathing, with 40% having central sleep apnea syndrome (CSA) and 11% with obstructive sleep apnea (OSAS).[7,8] A variant of central sleep apnea, Cheyne-Stokes respiration often coexists with central sleep apnea syndrome.[8] Central sleep apnea and/or Cheyne Stokes respiration (CSA/CSR) - by causing severely disordered sleep may impose pathophysiological consequences that adversely affect left ventricular structure and function and worsen prognosis.[9] The severity of sleep apnea in heart failure patients is typically high, with apnea-hypopnea indices approximating 40 events per hour in several reported studies.[7,9,10,11] Various treatment modalities are available for the treatment of sleep-disordered breathing in the setting of heart failure including medications, nocturnal supplemental oxygen therapy, and noninvasive positive airway pressure devices including continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP), and adaptive pressure support servoventilation (ASV). This article focuses on the reported benefits of ASV on heart failure patients with CSA/CSR.

In our experience, heart failure patients with CSA/CSR are technically difficult to titrate especially on CPAP, or BiPAP. Balancing the hemodynamic concerns of heart failure patients with attempts to find the ideal titration pressure is challenging, and frequently not achievable with CPAP or BiPAP. Several trials have reported subtherapeutic titrations with best apnea-hypopnea index (AHI) on CPAP of greater than 20/h.[11,12,13,14] Javaheri also reported on 12 central apnea patients who did not respond to CPAP with a CPAP-treated AHI of 62 + 29/h with no improvement in sleep quality indicators including arousal index, total sleep time, and sleep staging.[11] The Canadian Continuous Positive Airway Pressure Trial (CANPAP) recently reported a lack of benefit of CPAP on morbidity or mortality of patients with central sleep apnea and heart failure.[13] Their conclusion was their data did not support the use of CPAP to extend life in patients who have central sleep apnea and heart failure. Limitations with this trial are that patients assigned to CPAP still had a substantial apnea-hypopnea index of 20/h and marginal compliance with CPAP use at 4.3 hours/night at 3 months and 3.6 hours/night at one year and beyond. Perhaps, the reason is that there is a threshold for adverse cardiovascular consequences that lies below the threshold AHI achievable with CPAP.[15]

Adaptive pressure servoventilation is the only modality that offers promise in heart failure patients with CSA-CSR. Adaptive pressure support servoventilation is a device that provides variable amounts of ventilatory support during the different phases of Cheyne-Stokes respiration.[16] The adaptive servoventilation device continuously monitors and records recent average minute ventilation for 3 minute sampling periods (target ventilation) as a template to continually adjust the pressure support from 3 cm H_2O to 15 cm H_2O to achieve 90% of the target ventilation. The ASV algorithm automatically adjusts the magnitude of pressure support breath-by-breath to provide minimal, comfortable support during the over-breathing phase (hyperpnea) or normal breathing and increase support during the under-breathing phase (hypopnea or apnea). After equilibration of this process (40 minutes), the machine is set in CPAP mode to adjust the end expiratory pressure (EEP) in 1–2 cm increments to relieve upper airway obstruction.

Several studies have been published on adaptive servoventilation.[7,12,14,17] In one study, 14 patients with stable cardiac failure receiving optimal medical therapy were tested untreated, and subsequently on four treatment nights in random order the following modalities: nasal oxygen (2L/min), continuous positive airway pressure (mean CPAP 9.25 cm H_2O), bilevel positive airway pressure (mean 13.5/5.2 cm H_2O), or ASV largely on default settings.[12] The apnea-hypopnea index declined from 44.5 ± 3.4/h untreated to 28.2 ± 3.4/h with oxygen, 26.8 ± 4.6/h with CPAP, 14.8 ± 2.3/h with bilevel, and 6.3 ± 0.9/h with ASV. The arousal index was decreased dramatically, especially with bilevel and ASV (65.1 ± 3.9/hr untreated vs. 16 ± 1.3/h BiPAP and 14.7 ± 1.8/hr ASV). ASV was the only modality demonstrating large increases in slow wave and rapid eye movement sleep. All but one subject preferred sleeping with ASV. ASV demonstrated a definitive improvement in sleep quality. Another study, a randomized, prospective parallel trial assessed the effectiveness of adaptive servoventilation provided at therapeutic vs. subtherapeutic levels in stable, symptomatic chronic heart failure patients with Cheyne-Stokes breathing in 30 patients over a period of one month.[17] This study showed that ASV resulted in a significant improvement in daytime sleepiness measured by the maintenance of wakefulness test, and plasma brain natriuretic factor and urinary catecholamine excretion, which are markers of CHF prognosis.[17] The change in duration of wakefulness with therapeutic ASV was 8.9 minutes; the magnitude of this effect is considered large and equivalent to the 7-minute improvement produced in OSAS patients optimally treated with CPAP.[18] Therapeutic levels of ASV reduced the AHI to 5 ± 1.4/h compared to 20.6 ± 2.3 on subtherapeutic ASV. A recent trial from France compared the compliance and effectiveness of ASV versus continuous positive airway pressure (CPAP) in 25 patients with congestive heart failure and central sleep apnea syndrome, with Cheyne-Stokes respiration with endpoints including the apnea-hypopnea index, quality of life, and left ventricular ejection fraction over six months.[14] Both ASV and CPAP decreased the AHI, but, noticeably only ASV completely corrected CSA-CSR, with an AHI below 10/h. Compliance with treatment decreased significantly over time with CPAP, whereas it remained stable with ASV, and the improvement in quality of life was higher with ASV, and only ASV induced a significant increase in LVEF.

Although long term studies with large numbers of patients are necessary, preliminary studies suggest that ASV is superior in efficacy and the only modality which consistently corrects the AHI, improves sleep quality, improves compliance and may improve heart failure in patients with CSA-CSR. Because of the inconsistency of response to CPAP, perhaps it should be restricted to those heart failure patients with predominant OSAS.

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