

CLINICAL VIGNETTE

Heart Failure and Sleep Apnea Syndromes

Eugenia Wen, MD, Gregory Bierer, MD, Ravi Aysola, MD

Case Report

A 91-year-old male presented to an outside sleep clinic with complaints of excessive daytime sleepiness and nocturnal insomnia. The patient had no difficulty falling asleep but would arouse throughout the night snoring, choking and sometimes gasping for air. He snores moderately and his wife noted that he has had occasional pauses in his breathing during sleep. His symptoms have been present for the past 5 years and are progressively worsening. He nods off easily during the day at times of inactivity and his Epworth sleepiness scale score was elevated at 12/24 (normal 1-8). He denied nodding off while driving and had no history of motor vehicle accidents related to altered consciousness. He underwent an overnight polysomnography study which confirmed presence of mixed obstructive sleep apnea with an overall AHI 41.6/hr, OSA index 4/hr, CSA index 9/hr and hypopnea index of 28/hr. His oxygen saturation dropped to 82% from a baseline of 96% during his bouts of apnea. A CPAP titration study was recommended but the patient was unable to return to the sleep lab due to his unstable cardiac condition. The patient has an extensive history of ischemic cardiomyopathy with bouts of recurrent CHF and a cardiac pacer placement for sick sinus syndrome. He had New York Heart Association (NYHA) Functional Classification III/IV symptoms with persistent pulmonary congestion, bilateral pleural effusion as well as recurrent angina. His primary cardiologist had recommended hospice care. The patient is otherwise highly functional, living independently with his wife and managing their financial affairs. The couple came to UCLA cardiology service to seek a second opinion. The patient was medically optimized with adjustment of his cardiac medications and aggressive diuresis. His symptoms improved from NYHA Class III to I/II. His chest radiograph normalized with the resolution of congestion and effusions. With the improvement of his cardiac symptoms, the patient returned to the sleep laboratory for an overnight polysomnography study eight months after the initial diagnostic test. A split night study was performed and showed that the severity of his sleep apnea syndrome had reduced

with decrease of his overall AHI from 41.6/hr to 15.5/hr, with primarily obstructive episodes. A CPAP, then a BiPAP titration was initiated with resolution of apneic episodes at a BiPAP setting of 12/8 cm H₂O.

Introduction

Congestive heart failure (CHF) is the most common reason for hospitalization in the United States for those over 65 years. Heart failure costs Medicare and American insurance companies over 16 billion dollars each year. CHF also has a 50% 5 year mortality rate. Sleep apnea syndromes (SAS) frequently co-exist in patients with heart failure, complicating their treatment and increasing the mortality rate. Recognition and treatment of co-existing SAS are vital in the management of CHF patients, improving their quality of life and survival.

Definition

Sleep apnea syndrome is a disorder in which an individual's airflow ceases or is limited during sleep either from mechanical airway obstruction (obstructive sleep apnea) or loss of central drive of respiration (central sleep apnea). Obstructive sleep apnea (OSA) occurs when the upper airway narrows or collapses due to a loss of muscular tone during sleep. An obstructive apneic episode is defined as the total cessation of airflow for greater than 10 seconds despite the patient's continued effort to breathe with increasing force. When the airway is narrowed from the partial relaxation of pharyngeal and retroglossal musculatures, hypopneas occur and are defined as a reduction in airflow by 30% or greater and desaturation greater than 4% from baseline for greater than 10 seconds. The normal apnea-hypopnea index (AHI) is less than 5 events/hour. Central sleep apnea (CSA) is diagnosed by polysomnography or observation of cessation of respiratory effort for greater than 10 seconds.

Discussion

Prevalence of sleep apnea is very high in the congestive heart failure population. It ranged from 47% in Yumino's study¹ to 76% in Oldenberg's study of 700 patients with systolic heart failure². Cheyne-Stokes respiration is a form of central sleep apnea. Its crescendo-decrescendo pattern of respiration is best recognized and often associated with decompensated congestive heart failure. Patients with congestive heart failure commonly have both obstructive and central sleep apnea though one pattern will predominate over the other. Approximately 30% of central apneas will end with obstructive apnea as respiratory effort restarts against a collapsed airway at the end of the central pause³. In the Oldenberg study, 40% of the SAS patients had CSA and 36% had OSA. (2) This ratio is representative of other smaller studies.

Obstructive sleep apnea is a known cause and risk factor of CHF, increasing the patients' risk of mortality and morbidity⁴. Upper airway obstruction causes an increase in intrathoracic pressure which in turn compresses the heart resulting in an increase in transmural pressure of the left ventricular wall, an increase in left ventricular afterload and a reduction in cardiac output. Airway obstruction also activates the sympathetic nervous system with resultant increase in heart rate, O₂ consumption and vasoconstriction, further worsening cardiac stress. CHF, in turn, exacerbates OSA with extracellular fluid overload from declining cardiac function. Pharyngeal edema occurs, further narrowing the upper airway and increasing obstructive episodes and severity of apneas. Bucca's study showed reduction in apnea hypopnea index (AHI) in patients with OSA and CHF treated with diuretics⁵.

Central apnea results from the instability of ventilator control system with hyperresponsiveness in both the peripheral mechanoreceptors (pulmonary vagal irritant receptors) to venous congestion and central chemoreceptors to hypercarbia and hypoxemia causing hyperventilation. Hyperventilation, in turn, drops the serum PCO₂ level below the central apnea threshold, resulting in a loss of respiratory drive, causing central apnea³. CSA in the patients with CHF portends worse prognosis than those with CHF-OSA based on Baaker's study of CHF research cohort of 53 patients at 10 years follow up⁶.

In the case presentation, the patient has mixed obstructive and central sleep apnea. Hypopneas in general are difficult to characterize as obstructive or central in etiology. With aggressive diuresis and

optimization of CHF with medical treatment, the patient's AHI decreased from 41.6/hr to 15.5/hr, which is consistent with the current literature. Diuretic therapy improves OSA by reducing extravascular fluid collection, upper airway edema⁵. It decreases pulmonary capillary wedge pressure and pulmonary edema and thus improves CSA with less pulmonary vagal irritant receptor stimulation³. Captopril⁷ and carvedilol⁸ have also been shown to reduce CSA associated with CHF.

In stable CHF patients with OSA, CPAP therapy improves left ventricular function with an average increase in ejection fraction by 6%³. It also decreases overnight urinary norepinephrine excretion, daytime systolic blood pressure and left ventricular end-systolic diameter in patients with systolic heart failure^{9, 10}. In a study by Doherty et al, 150 patients with CHF and OSA were followed for 7.5 years. Cardiovascular disease mortality rates were compared between the group who were compliant with CPAP therapy and those who quit. CPAP compliant patients had reduced mortality rates in comparison to the patients who quit (1.9% vs 14.8% mortality rate, p=0.009)¹¹.

CPAP therapy in the patients with CSA and CHF has been shown to be ineffective in the CANPAP (Canadian Continuous Positive Airway Pressure for patients with central sleep apnea and heart failure) trial of 2005 due to the CPAP therapy's inability to reliably reduce AHI to normal range¹². But in the post hoc analysis of the CANAP data by Arzt et al with re-stratification of efficacy of treatment based residual AHI on CPAP therapy, improvements in transplant free survival and LVEF were seen in the population where CSA was adequately treated¹³.

American Academy of Sleep Medicine published practice parameters in 2012 on the treatment of CSA related to CHF. Optimizing medical treatment for CHF and stabilizing cardiac function is the first priority. After that, CSA can be corrected by using CPAP, Adaptive Servo-Ventilation (ASV) or nocturnal oxygen therapy. CPAP therapy should be attempted first and determined ineffective before an initiation of ASV. The cost of an ASV unit is at least seven times higher than CPAP unit. It offered no additional benefits over CPAP therapy if CPAP was effective in reducing AHI to normal range in CSA patients. As in patients with OSA, effective CPAP therapy in CSA patient also increases LVEF by 6-7% and improves survival.

Adaptive servo-ventilation is a bilevel closed loop mechanical ventilator. It is pressure pre-set and operates either volume or flow cycled, depending on the manufacturer and model. The expiratory pressure will fluctuate up and down to correct detected obstruction. Inspiratory pressure or flow will vary with the back up rate to correct for central apneas according to predetermined targets via computerized algorithms. Most studies on ASV are industry supported with moderate quality. In several studies comparing efficacy of ASV vs CPAP and BiPAP therapy, ASV improved AHI slightly better than CPAP and BiPAP but offered no further improvement of LVEF. BiPAP therapy was not superior to CPAP therapy in its ability to reduce AHI. The patients, however, do tolerate ASV better than CPAP therapy¹⁴⁻¹⁶.

Oxygen therapy is offered to patients who cannot tolerate PAP therapy. It can reduce both the AHI and sympathetic nervous system activation with improved mean nocturnal oxygen saturation. Oxygen therapy does not improve the patient's symptoms of daytime fatigue, cognitive function and nocturnal sleep quality. No adverse events were recorded with oxygen treatment.

Conclusion

Sleep apnea syndromes occur with high frequency in patients with heart failure, especially in those with reduced systolic function. Co-existence of both CHF and SAS increases a patient's mortality and morbidity rates. Overnight polysomnography (PSG) in laboratory should be ordered in all CHF patients who have typical complaints suggestive of SAS like snoring, excessive daytime sleepiness or fatigue and frequent nocturnal arousals secondary to dyspnea or snoring. One may also consider PSG evaluation in patients with nocturnal angina, recurrent arrhythmias, refractory CHF symptoms or observed abnormal nocturnal respiratory patterns. Ambulatory sleep studies are not recommended for this patient population. Optimization of CHF control with medications or further cardiac interventions as indicated is of utmost importance in improving survival of patients with heart failure. CPAP therapy is the first line treatment for patients with CHF and sleep apnea syndromes. ASV is an excellent treatment option if CPAP is ineffective. Oxygen therapy is an acceptable alternative if the patient is intolerant of PAP treatment.

REFERENCES

1. Yumino D, Wang H, Floras JS, Newton GE, Mak S, Ruttanaumpawan P, Parker JD, Bradley TD. Prevalence and physiological predictors of sleep apnea in patients with heart failure and systolic dysfunction. *J Card Fail*. 2009 May;15(4):279-85. doi: 10.1016/j.cardfail.2008.11.015. Epub 2009 Jan 21. PubMed PMID: 19398074.
2. Oldenburg O, Lamp B, Faber L, Teschler H, Horstkotte D, Töpfer V. Sleep-disordered breathing in patients with symptomatic heart failure: a contemporary study of prevalence in and characteristics of 700 patients. *Eur J Heart Fail*. 2007 Mar;9(3):251-7. Epub 2006 Oct 5. PubMed PMID: 17027333.
3. Sharma B, Owens R, Malhotra A. Sleep in congestive heart failure. *Med Clin North Am*. 2010 May;94(3):447-64. doi: 10.1016/j.mcna.2010.02.009. Review. PubMed PMID: 20451026; PubMed Central PMCID: PMC3424608.
4. Wang H, Parker JD, Newton GE, Floras JS, Mak S, Chiu KL, Ruttanaumpawan P, Tomlinson G, Bradley TD. Influence of obstructive sleep apnea on mortality in patients with heart failure. *J Am Coll Cardiol*. 2007 Apr 17;49(15):1625-31. Epub 2007 Apr 2. PubMed PMID: 17433953.
5. Bucca CB, Brussino L, Battisti A, Mutani R, Rolla G, Mangiardi L, Cicolin A. Diuretics in obstructive sleep apnea with diastolic heart failure. *Chest*. 2007 Aug;132(2):440-6. PubMed PMID: 17699130.
6. Bakker JP, Campbell AJ, Neill AM. Increased mortality risk in congestive heart failure patients with comorbid sleep apnoea: 10-year follow up. *Intern Med J*. 2012 Nov;42(11):1264-8. doi: 10.1111/j.1445-5994.2012.02904.x. PubMed PMID: 23157523.
7. Tamura A, Kawano Y, Kadota J. Carvedilol reduces the severity of central sleep apnea in chronic heart failure. *Circ J*. 2009 Feb;73(2):295-8. Epub 2008 Dec 27. PubMed PMID: 19122306.
8. Tamura A, Kawano Y, Naono S, Kotoku M, Kadota J. Relationship between beta-blocker treatment and the severity of central sleep apnea in chronic heart failure. *Chest*. 2007 Jan;131(1):130-5. PubMed PMID: 17218566.
9. Mansfield DR, Gollogly NC, Kaye DM, Richardson M, Bergin P, Naughton MT. Controlled trial of continuous positive airway pressure in obstructive sleep apnea and heart failure. *Am J Respir Crit Care Med*. 2004 Feb 1;169(3):361-6. Epub 2003 Nov 3. PubMed PMID: 14597482.
10. Kaneko Y, Floras JS, Usui K, Plante J, Tkacova R, Kubo T, Ando S, Bradley TD. Cardiovascular effects of continuous positive airway pressure in patients with heart failure and obstructive sleep apnea. *N Engl J Med*. 2003 Mar 27;348(13):1233-41. PubMed PMID: 12660387.
11. Doherty LS, Kiely JL, Swan V, McNicholas WT. Long-term effects of nasal continuous positive airway pressure therapy on cardiovascular outcomes in sleep apnea syndrome. *Chest*. 2005 Jun;127(6):2076-84. PubMed PMID: 15947323.
12. Bradley TD, Logan AG, Kimoff RJ, Séries F, Morrison D, Ferguson K, Belenkie I, Pfeifer M, Fleetham J, Hanly P, Smilovitch M, Tomlinson G, Floras JS; CANPAP Investigators. Continuous positive airway pressure for central sleep apnea and heart failure. *N Engl J Med*. 2005 Nov 10;353(19):2025-33. PubMed PMID: 16282177.
13. Arzt M, Floras JS, Logan AG, Kimoff RJ, Series F, Morrison D, Ferguson K, Belenkie I, Pfeifer M, Fleetham J, Hanly P, Smilovitch M, Ryan C, Tomlinson G, Bradley TD; CANPAP Investigators. Suppression of central sleep apnea by continuous positive airway pressure

- and transplant-free survival in heart failure: a post hoc analysis of the Canadian Continuous Positive Airway Pressure for Patients with Central Sleep Apnea and Heart Failure Trial (CANPAP). *Circulation.* 2007 Jun 26;115(25):3173-80. Epub 2007 Jun 11. PubMed PMID:17562959.
14. **Hu K, Li QQ, Yang J, Chen XQ, Hu SP, Wu XJ.** The role of high-frequency jet ventilation in the treatment of Cheyne-Stokes respiration in patients with chronic heart failure. *Int J Cardiol.* 2006 Jan 13;106(2):224-31. Epub 2005 Aug 26. PubMed PMID: 16126290.
15. **Teschler H, Döhring J, Wang YM, Berthon-Jones M.** Adaptive pressure support servo-ventilation: a novel treatment for Cheyne-Stokes respiration in heart failure. *Am J Respir Crit Care Med.* 2001 Aug 15;164(4):614-9. PubMed PMID:11520725.
16. **Allam JS, Olson EJ, Gay PC, Morgenthaler TI.** Efficacy of adaptive servoventilation in treatment of complex and central sleep apnea syndromes. *Chest.* 2007 Dec;132(6):1839-46. PubMed PMID: 18079219.

Submitted on May 29, 2013