First Experience of Using New Adaptive Servo-Ventilation Device for Cheyne-Stokes Respiration With Central Sleep Apnea Among Japanese Patients With Congestive Heart Failure
—— Report of 4 Clinical Cases ——

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Background Cheyne-Stokes respiration with central sleep apnea (CSR-CSA) in congestive heart failure (CHF) is generally considered a poor prognostic indicator, but treatment of CSR-CSA using an adaptive servo-ventilation (ASV) device has been developed. This is the first evaluation of its use in the management of CSR-CSA in Japanese CHF patients.

Methods and Results Four CHF patients with CSR-CSA that was unresponsive to conventional positive airway pressure (CPAP) underwent 3 nights of polysomnography: baseline, CPAP or bi-level PAP, and on the ASV. The apnea–hypopnea index (AHI) and central-AHI (CAHI) were markedly improved on ASV (AHI 62.7±10.1 to 5.9±2.2/h, p=0.0006, CAHI 54.5±6.7 to 5.6±2.3/h, p=0.007). In addition, the sleep quality improved significantly on ASV, including arousal index (62.0±10.5 to 18.7±6.2/h, p=0.012), percentage of slow-wave sleep (2.6±2.6 to 19.4±4.8 %, p=0.042).

Conclusions ASV markedly improved CSR-CSA in patients with CHF. It is a promising treatment for Japanese patients with CHF. (Circ J 2006; 70: 1148–1154)

Key Words: Adaptive-servo ventilation; Bi-level positive airway pressure; Central sleep apnea; Cheyne-Stokes respiration; Congestive heart failure; Continuous positive airway pressure

Several studies have shown that patients with congestive heart failure (CHF) often suffer from the complication of abnormal periodic breathing during sleep, including Cheyne-Stokes respiration with central sleep apnea (CSR-CSA). Patients with CSR-CSA have a poorer prognosis than CHF patients without CSR-CSA1–3. To date, CSR-CSA has been treated with positive airway pressure (PAP), including continuous PAP (CPAP) and bi-level PAP4,5 but although these devices reduce the incidence of apnea, and improve the sleep quality and cardiac function in CHF patients with CSR-CSA, there are some patients who show either no acute improvement or incomplete management of the abnormal breathing pattern6. To be effective, CPAP requires spontaneous breathing, and it may sometimes not be effective for frank central apnea. In addition, compliance with CPAP is sometimes poor because patients feel uncomfortable when they exhale against the high positive pressures required for appropriate treatment7. This may have contributed to the results of recent clinical trials, the Canadian Continuous Positive Airway Pressure Trial for Congestive Heart Failure (CANPAP), which failed to show long-term mortality benefits in CHF patients with CSR-CSA using CPAP8. Therefore, other alternatives need to be considered when treating CHF patients with CSR-CSA. We previously reported on the efficacy of another PAP device, bi-level PAP, for improving the abnormal breathing pattern or underlying cardiac dysfunction in these patients9,10. However, in the clinical setting, patients often continue to present with the CSA-CSR breathing pattern. More recently, the adaptive-servo ventilator (ASV), a novel PAP device, has been established as an effective therapeutic alternative to other PAP technologies. The ASV not only manages the sleep disordered breathing, but also may improve cardiac function11–13. The ASV device was only recently available for use in Japan, and experience in the Japanese patient population has been unreported. Therefore, we now report the first clinical experience using the ASV device among Japanese CHF patients with CSR-CSA. These subjects continued to have CSR-CSA after using other traditional PAP therapies, including CPAP and bi-level PAP.

Methods

Subjects
We enrolled patients who have been diagnosed as having...
CSR-CSA and chronic CHF and were being followed in Toranomon Hospital (Tokyo, Japan). These subjects included patients for whom PAP therapy had already been attempted, but which had failed to resolve the CSR-CSA or the patient had poor compliance with the traditional device (defined as ≤70% of nights used, ≤4 h/night over 1 month of usage). All 4 successful candidates gave informed consent and the trial was performed according to the ethics policies of the institution.

Case 1 had attempted bi-level PAP therapy (BiPAP Synchrony, Respironics, PA, USA) using S/T mode, with the inspiratory PAP (IPAP) set to 12 cmH2O, expiratory PAP (EPAP) set to 6 cmH2O, and the back-up respiratory rate set to 16/min. The PAP device did not completely eliminate the respiratory events because this patient required a very high pressure support (PS) to sustain ventilation during back-up breathing spanning central apneas. Such high pressure was deemed too uncomfortable, and woke the patient. Thus, the CSR-CSA could not be completely eliminated.

Case 2 had also attempted bi-level PAP therapy (BiPAP Synchrony, Respironics) using S/T mode, IPAP 15 cmH2O, EPAP 9 cmH2O, and back-up respiratory rate 15/min. As with the previous subject, the device failed to provide sufficient relief for the CSA-CSR.

Case 3 had been started on CPAP therapy (REmstar Auto, Respironics, PA, USA) at 6 cmH2O, but it failed to manage the CSR-CSA. This subject was poorly compliant and complained about the uncomfortable sensation of excessive exhalatory pressure.

Case 4 had also been started on CPAP therapy (REmstar Auto, Respironics, 7 cmH2O) because of both the cost and the difficulty in synchronizing to bi-level PAP therapy. His CSR-CSA was modestly reduced but his compliance was poor, possibly because of the sensation of high exhalatory pressure.

Sleep Study

All participants underwent a nocturnal in-lab attended polysomnography (PSG) using a digital polygraph (SomnoStar Alpha Sleep System, Sensor Medics, CA, USA). The standard PSG recorded the central electroencephalograms, bilateral electro-oculograms, submental electromyogram, bilateral anterior tibialis electromyogram, electrocardiogram, chest and abdominal movement recording using respiratory effort bands, body position monitoring, oronasal airflow monitoring using a pressure-sensor, and arterial oxyhemoglobin saturation monitoring using a pulse-oximeter.

The sleep study was scored using standard methodologies. Sleep staging and arousals were scored using 30-s epochs according to Rechtschaffen and Kales and the American Academy of Sleep Medicine criteria. Classification of apnea and hypopnea used standard methodologies, as previously described. The apnea–hypopnea index (AHI) was defined as the total number of apnea and hypopnea events divided by the total sleep time (TST), and was expressed as the number of events per hour. The arousal index (Arl) was defined as the total number of arousals divided by the TST, and was expressed as the number of events per hour. Sleep stages 1 and 2, slow-wave sleep (SWS) and rapid eye movement (REM) sleep were scored as a percentage of TST. Each subject underwent 3 PSG recordings: initial baseline diagnostic recording, second recording on the conventional PAP device (either CPAP or bi-level PAP), and then while using the new ASV device.

ASV

In the present study, all subjects used the same type of ASV device (Heart PAP, Respironics, PA, USA). This device is a noninvasive ventilator intended for use in patients with sleep disordered breathing, including CSA-CSR. Therapy is intended to be used by the patient via either a

### Table 1 Clinical Characteristics of the 4 Patients With CSR-CSA

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age (years)</th>
<th>Gender</th>
<th>BMI (kg/m²)</th>
<th>Etiology of CHF</th>
<th>LVEF (%)</th>
<th>BNP (pg/ml)</th>
<th>NE (pg/ml)</th>
<th>NYHA class</th>
<th>PaO₂ (Torr)</th>
<th>PaCO₂ (Torr)</th>
<th>ESS</th>
<th>Medication</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>M</td>
<td>29.0</td>
<td>Non IHD</td>
<td>43</td>
<td>189</td>
<td>781</td>
<td>III</td>
<td>76</td>
<td>39</td>
<td>17</td>
<td>ARB, BB, Sp, Dia, Dig</td>
</tr>
<tr>
<td>2</td>
<td>77</td>
<td>M</td>
<td>26.0</td>
<td>Non IHD</td>
<td>45</td>
<td>206</td>
<td>448</td>
<td>II</td>
<td>92</td>
<td>36</td>
<td>15</td>
<td>ARB, BB, Dia, Dig, ACEI, BB</td>
</tr>
<tr>
<td>3</td>
<td>62</td>
<td>M</td>
<td>29.8</td>
<td>IHD</td>
<td>29</td>
<td>314</td>
<td>678</td>
<td>II</td>
<td>80</td>
<td>36</td>
<td>12</td>
<td>Sp, Dia, Am</td>
</tr>
<tr>
<td>4</td>
<td>85</td>
<td>M</td>
<td>19.9</td>
<td>IHD</td>
<td>35</td>
<td>564</td>
<td>570</td>
<td>III</td>
<td>86</td>
<td>39</td>
<td>15</td>
<td>ACEI, BB, Sp, Dia, Am</td>
</tr>
<tr>
<td>Mean</td>
<td>72.3</td>
<td></td>
<td>26.2</td>
<td></td>
<td>37.9</td>
<td>318.3</td>
<td>619.3</td>
<td></td>
<td>83.5</td>
<td>37.5</td>
<td>14.8</td>
<td></td>
</tr>
</tbody>
</table>

CSR-CSA, cheyne-stokes respiration with central sleep apnea; BMI, body mass index; CHF, congestive heart failure; LVEF, left ventricular ejection fraction; BNP, brain natriuretic peptide; NE, norepinephrine; NYHA, New York Heart Association functional; ESS, epworth sleepiness scale; IHD, ischemic heart disease; ARB, angiotensin II receptor blockers; BB, β-blockers; Sp, spironoractone; Dia, diuretics; Dig, digoxin; ACEI, angiotensin converting enzyme inhibitors; Am, amiodarone; SEM, standard error of the mean.

### Table 2 Diagnostic Polysomnography Findings

<table>
<thead>
<tr>
<th>Case no.</th>
<th>AHI (no./h)</th>
<th>% of TST</th>
<th>Lowest SO₂ (%)</th>
<th>ArI (no./h)</th>
<th>Sleep stage (% of TST)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>87.3</td>
<td>67.4</td>
<td>19.9</td>
<td>34.7</td>
<td>64</td>
</tr>
<tr>
<td>Central</td>
<td>62.6</td>
<td>51.5</td>
<td>11.1</td>
<td>22.8</td>
<td>74</td>
</tr>
<tr>
<td>Obstructive</td>
<td>38.0</td>
<td>37.1</td>
<td>0.9</td>
<td>1.5</td>
<td>77</td>
</tr>
<tr>
<td>Mean</td>
<td>62.8</td>
<td>62.0</td>
<td>0.8</td>
<td>8.8</td>
<td>81</td>
</tr>
<tr>
<td>SEM</td>
<td>10.1</td>
<td>6.7</td>
<td>4.6</td>
<td>7.4</td>
<td>3.6</td>
</tr>
</tbody>
</table>

AHI, apnea–hypopnea index; TST, total sleep time; SO₂, arterial oxyhemoglobin saturation; ArI, arousal index; SWS, slow wave sleep; REM, rapid eye movement; SEM, standard error of the mean.
nasal or full-face mask in the home or clinical setting. Although the ASV has several modes of therapy available, only the auto mode was used in this study.

Under normal operation of the ASV, the management of any obstructive component of sleep disordered breathing is performed using a previously titrated CPAP or bi-level pressure setting. The clinician sets the EPAP and minimum IPAP (IPAP\textsubscript{min}) levels to maintain airway patency by management of any obstructive sleep disordered breathing. This is typically performed during a traditional in-laboratory monitored titration PSG study. If clinically appropriate, EPAP and IPAP\textsubscript{min} can be set to the same value, offering the patient a baseline therapy of CPAP. A maximum IPAP (IPAP\textsubscript{max}) is set according to clinical presentation, and is typically set 15 cmH\textsubscript{2}O greater than IPAP\textsubscript{min}.

When a CSR-CSA event begins, the PS, the difference

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### Table 3 Effect of Treatment on Polysomnography Findings

<table>
<thead>
<tr>
<th></th>
<th>At diagnosis</th>
<th>On conventional PAP*</th>
<th><em>p value</em>*</th>
<th>On ASV</th>
<th><em>p value</em>*</th>
<th><em>p value</em>**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AHI (no./h)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>62.7±10.1</td>
<td>17.8±3.3</td>
<td>0.021</td>
<td>5.9±2.2</td>
<td>0.0006</td>
<td>0.047</td>
</tr>
<tr>
<td>Central</td>
<td>54.5±6.7</td>
<td>13.5±1.5</td>
<td>0.02</td>
<td>5.6±2.3</td>
<td>0.007</td>
<td>0.053</td>
</tr>
<tr>
<td>Obstructive</td>
<td>8.2±4.6</td>
<td>4.3±1.8</td>
<td>0.86</td>
<td>0.3±0.1</td>
<td>0.029</td>
<td>0.084</td>
</tr>
<tr>
<td><strong>Sleep stage (% of TST)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWS</td>
<td>2.6±2.6</td>
<td>11.9±4.1</td>
<td>0.24</td>
<td>19.1±4.8</td>
<td>0.042</td>
<td>0.33</td>
</tr>
<tr>
<td>REM</td>
<td>7.9±3.9</td>
<td>14.7±3.4</td>
<td>0.60</td>
<td>18.4±4.4</td>
<td>0.21</td>
<td>0.69</td>
</tr>
</tbody>
</table>

\*Conventional positive airway pressure (PAP), continuous PAP or bi-level PAP.
** vs diagnosis, ***conventional PAP vs ASV.

PAP, positive airway pressure; ASV, adaptive servo-ventilation. Other abbreviations see in Table 2.

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Fig 1. Effect of treatment on the apnea–hypopnea index (AHI). (A) Total AHI. Significant reductions in the total AHI with both conventional positive airway pressure (PAP), including continuous PAP and bi-level PAP (p=0.02), and adaptive servo-ventilation (ASV) (p=0.0006) were observed. There were significant differences between the AHI on conventional PAP and on ASV (17.8±3.3 vs 5.9±2.2 /h, p=0.047). (B) Central AHI (CAHI): significant reductions of the CAHI with both conventional PAP (p=0.02) and ASV (p=0.007) were observed. There was a tendency for the CAHI to reduce more on ASV than on conventional PAP (13.5±1.5 vs 5.6±2.3 /h, p=0.053). (C) Obstructive AHI (OAHI): significant reductions in the OAHI were observed only on ASV (p=0.029). Data are presented individually: (\textcircled{1}) diagnosis and on ASV, (\textcircled{2}) treatment with conventional PAP. Mean and standard error of the mean are also presented.
between the IPAP and the EPAP pressures, increases and the gradually increasing PS provides augmented ventilation in an attempt to achieve a target peak flow. As the patient’s spontaneous respiratory effort improves, the PS provided by the ASV gradually decreases, which helps prevent extension of hyperventilation during the typical hyperpnea following the CSR ‘waning’ period. The serial application of this additional ventilatory support is intended to normalize patient ventilation and eliminate the persistent CSR-CSA phenomenon. Should frank apnea events occur, the ASV will attempt to ventilate the patient according to an internal algorithm, providing ventilatory support using back-up breaths delivered during the apnea event.

In the present study, the setting of the ASV device was determined before the sleep study as follows.

(a) The initial EPAP level was determined by the previously set pressure on other devices (the CPAP level or the EPAP level for bi-level PAP).

(b) If the patient has been on bi-level PAP initially, the IPAP_min was set to the previous IPAP level to eliminate any obstructive flow limitation.

(c) For this study, the IPAP_max was set to between 10 and 20cmH2O above the baseline maintenance pressures.

Table 4 Individual Settings for the Adaptive Servo-Ventilation Device

<table>
<thead>
<tr>
<th>Case no.</th>
<th>IPAP_max</th>
<th>IPAP_min</th>
<th>EPAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

IPAP_max, maximum inspiratory positive airway pressure; IPAP_min, minimum inspiratory positive airway pressure; EPAP, expiratory positive airway pressure.

A maximum pressure of greater than 20cmH2O was avoided, in order to lessen the chance of direct pressure-related compromise in cardiac output, as well as the chance that excessive PS would awaken the patients. The overriding objective during the study was to minimize the intrathoracic pressure to which the patient was exposed during the course of the therapy.

Measurements

In the current study changes between the diagnostic study and the subsequent studies under therapy were measured. Parameters of interest included total AHI, central AHI...
Fig 3. Representative raw wave form on polysomnography (PSG) from 1 patient. (A) Typical Cheyne-Stokes respiration with central sleep apnea (CSR-CSA) on the diagnostic PSG; note 4 central apneas and subsequent hyperventilation. (B) Improvement of CSR-CSA with adaptive servo-ventilation (ASV) on PSG; note the back-up ventilation during a central apnea with maximum inspiratory positive airway pressure and the reduction toward the minimum inspiratory positive airway pressure (IPAP_min) during the hyperventilation phase. (C) Spontaneous breathing with the ASV on PSG; note the adaptation of the ASV with IPAP_min on spontaneous inspiration and expiratory PAP on spontaneous expiration. EOG, electro-oculogram; EMG, submental electromyogram; EEG, electroencephalogram; ECG, electrocardiogram; SpO₂, oxyhemoglobin saturation.
Statistical Analysis

All values are mean ± standard error of the mean (SEM). The comparisons of each PSG parameter between the diagnostic sleep study and the subsequent study with either the conventional PAP devices (CPAP or bi-level PAP) or the ASV, and between the second study and third study were performed using the exact nonparametric permutation test, in which the permutation sample size was 10,000. In this analysis, data were rank transformed because of the small number of subjects assessed. Additionally, the comparison of each PSG parameter between the second study on conventional PAP and the third study on ASV was performed with the exact nonparametric permutation test, as well. P values of less than 0.05 were considered to indicate a statistically significant difference.

Results

Four patients agreed to participate in the trial of the ASV. There were no adverse events during overnight use of the device, nor were there complaints from the patients about 1-night use of the ASV. The characteristics and drug use of all 4 patients are shown in Table 1. Patients were older-aged males who had symptomatic chronic CHF with moderately or severely impaired left ventricular ejection fraction. Most of them were obese except for Case 4 whose body mass index was only 19 kg/m². They had been treated with conventional medication for chronic CHF, including angiotensin-converting enzyme inhibitors, angiotensin II receptor blockers, and/or β-blockers.

The diagnostic PSG findings of each patient are shown in Table 2. Patients revealed moderate to severe sleep apnea that predominantly consisted of CSR-CSA. All had severely disturbed sleep. All patients underwent their second PSG on their previous CPAP or bi-level PAP pressure settings.

The changes in each PSG parameter between the diagnostic study and the second study on conventional PAP device or the third on ASV are summarized in Table 3 and changes in the parameters of each patient are shown in Figs 1 and 2. The setting of the ASV during the third sleep study in each patient is shown in Table 4. The ASV markedly improved the total AHI (62.7±10.1/h to 5.9±2.2/h, p=0.0006),CAHI (54.5±6.7/h to 5.6±2.3/h, p=0.007) and OAH (8.2±6.6/h to 5±3.6/h, p=0.029). These levels of AHI are consistent with normal and furthermore, the improvement in AHI was significantly greater on the ASV than on conventional PAP (17.8±3.3/h on conventional PAP vs 5.9±2.2/h, p=0.047). Moreover, the ASV significantly improved sleep quality, with a reduction in the ArI (62.0±10.5/h to 18.7±6.2/h, p=0.012) and an increase in the proportion of SWS (2±6.2% to 9±4.8%, p=0.042). The REM sleep increased, although it is not statistically significant (7.9±3.9% to 18.4±4.4%, p=0.21). Representative wave forms in the diagnostic and third PSG are shown in Fig 3. There was a tendency to reduce the CAHI more on the ASV than on conventional PAP (13.5±1.5/h on conventional PAP vs 5.6±2.3/h on ASV, p=0.053). The improvement in the OAH and SWS was observed only on ASV. Although the improvements in ArI and REM sleep with the ASV were greater than those on conventional PAP therapy, the differences between the therapies were not significant.

The acute response to the ASV by all patients was better. In fact, although there are more than 3 awakenings in each case during the second PSG on conventional PAP, but none during the third PSG on ASV, except for 1 awakening in case 4, under the condition of no differences in TST between the 2 occasions. In addition, there were no complaints about uncomfortable sensations from either case 3 or 4, even though the same level of expiratory pressure was used for ASV and CPAP. Cases 1 and 2 continued to use the ASV device with good compliance, but cases 3 and 4 discontinued their use, not because of poor compliance but for cost reasons.

Discussion

The present study showed the CSR-CSA in CHF patients significantly improved when using the new ASV device. The ASV has 2 novel therapeutic algorithms. The primary algorithm is a pressure control system that normalizes patient ventilation levels by adjusting the inspiratory pressure and the secondary algorithm is an automatic timed back-up system that allows the patient to take natural pauses in inspiration while still providing PS assistance during true apneas. The pressure control system closely monitors the peak inspiratory flow of the patient and compares it to an internal target calculated as the patient’s average normal breathing pattern (peak flow). PS is dynamically adjusted breath to breath as necessary to ensure that the patient’s actual inspiratory flow matches the target. The automatic timed back-up system tracks the patient’s spontaneous breath rate and time of inspiration. Based on these data, a back-up breath is automatically delivered to the patient during an apnea event.

The residual CSR-CSA of the 4 patients was not resolved completely with conventional PAP therapy (bi-level PAP or CPAP), which is an important finding because in Japan many heart failure patients with sleep disordered breathing do not use either CPAP or bi-level PAP therapy. In those who do, the CSR-CSA is not completely managed either because of the intrinsic limitations of the therapy or patient compliance issues. The ASV may provide improved management of these cases now that it has been approved for clinical use in Japan.

The recent report of the Canadian trial of Continuous Positive Airway Pressure for management of CSR-CSA in a heart failure population (CANPAP) failed to show long-term mortality, hospitalization, and transplant-free survival benefit with CPAP. Thus, conventional CPAP should be used cautiously to treat current CHF patients with CSR-CSA and other alternative treatments may need to be considered to improve the poor outcome among patients with CHF.1–3

Many questions remain unanswered in the CANPAP trial; however the method of applying pressure to the patient (often without titration) certainly raises the question of untoward consequences of hemodynamic compromise secondary to higher intrathoracic pressures in these patients. In our study, the ASV was set to provide the absolute minimum pressure necessary to support the airway to prevent obstructive sleep disordered breathing. Higher pressures were only used during episodes of CSR-CSA hypopnea or apnea, with a rapid return to baseline pressure.

We previously reported the efficacy of bi-level PAP for...
CSR-CSA in CHF patients but the ASV was not yet available at the time of that study. The current study included 2 subjects for whom the use of conventional bi-level therapy was impractical and who were better managed using the ASV. In general, the combination of OSA and CSR-CSA often occurs in CHF patients and the ability of the ASV to manage both obstructive and CSR-CSA means that more patients can be managed by this therapy. Javaheri reported that 49% of CHF patients had significant sleep disordered breathing, 37% of them having CSR-CSA combined with OSA, and 12% of them having OSA as well as CSR-CSA. CPAP has been established as the therapy for OSA, even in the CHF patients but is sometimes ineffective for ceasing a central apnea event. Bi-level PAP is effective for both OSA and CSR-CSA, but in practice, such patients tend to require the IPAP level be set to lower values, because of the perceived difficulty with higher PS, and such reduction in IPAP often leads to insufficient management of the CSR-CSA. The ASV is able to resolve this problem of bi-level PAP, because the IPAP level is automatically and appropriately adapted.

There have been similar improvements reported in sleep quality, expressed by ArI, percentages of SWS and REM sleep. The improvement in sleep quality may affect the perception of sleepiness and this, coupled with the device’s algorithmic tendency to minimize applied pressures, may further improve the long-term compliance with therapy in such patients.

The present study showed only an acute improvement in CSR-CSA and there were no data about chronic use of this device. Further, only sleep specific outputs were evaluated and improvement in cardiac functions and quality of life have not been demonstrated. Several clinical studies in Western countries have shown the efficacy of chronic use of similar ASV devices on cardiac function and quality of life. Therefore, further investigations of chronic use and assessment of cardiac function are also needed in Japanese CHF patients.

Conclusion

The CSR-CSA among 4 Japanese patients with CHF, which was uncontrolled using conventional PAP therapies, was adequately and immediately controlled using the ASV device. These early and encouraging findings suggest that the long-term application of this novel therapy in the Japanese CHF population must be evaluated in subsequent prospective studies.

Acknowledgment

The authors acknowledge the advice and contribution of Professor W. J. Randerath (Universität Witten/Herdecke, Germany) in the management of patients undergoing ASV therapy.

References


