Effect of Flow-Triggered Adaptive Servo-Ventilation Compared With Continuous Positive Airway Pressure in Patients With Chronic Heart Failure With Coexisting Obstructive Sleep Apnea and Cheyne-Stokes Respiration

Takatoshi Kasai, MD, PhD; Yasuhiro Usui, MD; Toru Yoshioka, MD, PhD; Naotake Yanagisawa, PhD; Yoshifumi Takata, MD; Koji Narui, MD; Tetsu Yamaguchi, MD; Akira Yamashina, MD; Shin-ich Momomura, MD; for the JASV Investigators

**Background**—In patients with chronic heart failure (CHF), the presence of sleep-disordered breathing, including either obstructive sleep apnea or Cheyne-Stokes respiration-central sleep apnea, is associated with a poor prognosis. A large-scale clinical trial showed that continuous positive airway pressure (CPAP) did not improve the prognosis of such patients with CHF, probably because of insufficient sleep-disordered breathing suppression. Recently, it was reported that adaptive servo-ventilation (ASV) can effectively treat sleep-disordered breathing. However, there are no specific data about the efficacy of flow-triggered ASV for cardiac function in patients with CHF with sleep-disordered breathing. The aim of this study was to compare the efficacy of flow-triggered ASV to CPAP in patients with CHF with coexisting obstructive sleep apnea and Cheyne-Stokes respiration-central sleep apnea.

**Methods and Results**—Thirty-one patients with CHF, defined as left ventricular ejection fraction <50% and New York Heart Association class ≥II, with coexisting obstructive sleep apnea and Cheyne-Stokes respiration-central sleep apnea, were randomly assigned to either CPAP or flow-triggered ASV. The suppression of respiratory events, changes in cardiac function, and compliance with the devices during the 3-month study period were compared. Although both devices decreased respiratory events, ASV more effectively suppressed respiratory events (ΔAHI [apnea-hypopnea index] = −35.4 ± 19.5 with ASV; −23.2 ± 12.0 with CPAP, P<0.05). Compliance was significantly greater with ASV than with CPAP (5.2 ± 0.9 versus 4.4 ± 1.1 h/night, P<0.05). The improvements in quality-of-life and left ventricular ejection fraction were greater in the ASV group (ΔLVEF [left ventricular ejection fraction], +9.1 ± 4.7% versus +1.9 ± 10.9%).

**Conclusions**—These results suggest that patients with coexisting obstructive sleep apnea and Cheyne-Stokes respiration-central sleep apnea may receive greater benefit from treatment with ASV than with CPAP. *(Circ Heart Fail. 2010;3: 140-148.)*

**Key Words:** heart failure ■ pressure ■ sleep ■ ventilation

Heart failure (HF) has been reported that ~50% of patients with chronic heart failure (CHF) have sleep-disordered breathing (SDB),1–4 which consists of obstructive sleep apnea (OSA) caused by upper airway obstruction during sleep and Cheyne-Stokes respiration (CSR)-central sleep apnea (CSA) caused by respiratory control system instability. The presence of SDB, including both OSA and CSR-CSA, is known to be associated with increased mortality in patients with CHF.5–8

**Clinical Perspective on p 148**

In patients with CHF, treatment of SDB has been shown to improve underlying cardiac dysfunction. In particular, treatment with continuous positive airway pressure (CPAP) has been shown to suppress the abnormal breathing pattern, attenuate sympathetic overactivity, and improve left ventricular ejection fraction (LVEF) in patients with CHF with either OSA or CSR-CSA.9–12 However, it remains controversial whether CPAP should be a specific therapeutic option in patients with CHF with SDB, because randomized clinical trials assessing the long-term efficacy of CPAP in patients with CHF with OSA are lacking. In addition, a large-scale randomized clinical trial, the Canadian Continuous Positive Airway Pressure for Patients with Central Sleep Apnea and Heart Failure, in which the long-term efficacy of CPAP in
patients with CHF with CSR-CSA was investigated, showed that CPAP did not improve transplant-free survival in association with its insufficient alleviation of SDB.13 On the other hand, it is well recognized that compliance with CPAP can be problematic in treating SDB, particularly in patients with CHF. Therefore, other treatment options that can suppress SDB more effectively and can produce better compliance are needed to resolve the issue of whether patients with heart failure should be treated for SDB, when present.

From this perspective, adaptive servo-ventilation (ASV) may be an effective alternative for suppression of SDB.14 Indeed, several groups have reported the efficacy of ASV for suppressing SDB using 2 different types of ASV: volume-triggered ASV, and the newer, flow-triggered ASV, which has been developed based on the concept of normalizing breathing in patients with both OSA and CSR-CSA.15–17 Although several reports have demonstrated the efficacy of volume-triggered ASV for improving device compliance and cardiac function in patients with predominant CSR-CSA,18–20 there are no similar data showing such efficiencies using flow-triggered ASV. Moreover, no data about the efficacy of ASV for patients with CHF with coexisting OSA and CSR-CSA are available. Therefore, we hypothesized that, compared with CPAP, flow-triggered ASV would result in better compliance with the device and greater improvement in cardiac function in patients with CHF with coexisting OSA and CSR-CSA.

Methods

Subjects

This study was a prospective, parallel, randomized, multicenter trial. Subjects were enrolled based on the following criteria: (1) the presence of symptomatic CHF, which was defined as an LVEF <50% on echocardiography and New York Heart Association class ≥II; (2) stable clinical status, which was defined as receiving optimal medical therapy and no hospital admissions 1 month before study enrollment; and (3) diagnosed as having moderate-to-severe SDB, which was defined as ≥15 apnea or hypopnea events per hour of sleep (ie, apnea-hypopnea index [AHI]) with coexisting OSA (obstructive AHI ≥5 events/h) and CSR-CSA. The exclusion criteria were (1) age <20 or ≥80 years; (2) CHF primarily because of organic valvular heart disease; (3) on cardiac resynchronization therapy; (4) the presence of chronic pulmonary disease; (5) on dialysis; (6) history of stroke with neurological deficit; and (7) patients who had already started or had previously tried positive airway pressure therapy. All patients gave their written informed consent to participate in this study. This study was approved by the ethics committees of the involved institutions.

Sleep Study

SDB was diagnosed based on the results of overnight, in-laboratory, attended polysomnography. Generally accepted definitions and scoring methods were used.21–23 Obstructive and central events were scored as previously described.24 CSR was defined as follows: (1) at least 10 consecutive minutes.23

Intervention

After their baseline sleep study, the eligible subjects were randomly allocated into 2 groups: patients who received CPAP (REMStar Auto C-Plex, Respironics, Murrysville, Pa) or those who received flow-triggered ASV (HEART PAP, Respironics). Then, the patients underwent a titration of the allocated device during a second, overnight, in-laboratory, attended polysomnography.

In the CPAP group, airway pressure was manually modulated from 4 cm H2O to the effective pressure, with a maximum of 12 cm H2O. The appropriate fixed pressure was chosen as the pressure abolishing or significantly decreasing both obstructive events (including apnea, hypopnea, and snoring) and CSR without arousal.

The principle of operation of the flow-triggered ASV has been described previously.15–17 In summary, the flow-triggered ASV provides a manually set level of expiratory positive airway pressure (EPAP) to maintain upper-airway patency and automatically modulates the inspiratory positive airway pressure (IPAP) within a preset range to maintain a target inspiratory airflow, thereby eliminating CSR-CSA events. In addition, the device provides an automatic back-up rate, should sustained apnea be detected. In the ASV group, the EPAP was manually titrated from 4 cm H2O to the effective pressure, with a maximum of 10 cm H2O, using a similar titration method to that used for CPAP. The minimal IPAP was set at the determined EPAP level or to EPAP +2 cm H2O in patients with obstructive flow limitation. The maximal IPAP was set to 10 cm H2O greater than IPAP min. In addition, all subjects were initially set to an automatic back-up rate. When the central apneas were not corrected, the automatic back-up rate was changed to the fixed back-up rate of 10 breaths per minute or more. Subsequently, if continued periodic breathing (ie, CSR) was observed, maximal IPAP was raised by 2 cm H2O. A schema of the ASV titration algorithm is shown in Figure 1.

All subjects were assessed for compliance with treatment every month during the 3-month study period. Compliance was measured as the machine use (hours each night) given by the built-in counter. Provided pressure during use was also recorded in the device, and the mean value for the follow-up period was automatically calculated.

Measurements

The effectiveness of treatment of SDB evaluated by overnight, in-laboratory, attended polysomnography was assessed 3 months after initiation of each treatment.

At the time of hospitalization for the diagnostic and follow-up sleep studies, body mass index, blood pressure, heart rate, LVEF, left ventricular end-diastolic diameter, left ventricular end-systolic diameter, plasma brain natriuretic peptide (BNP), 24-hour urinary nor-epinephrine excretion, the distance walked in 6 minutes, sleepiness, and quality-of-life (QOL) were assessed. Two-dimensional echocardiographic images were obtained from the parasternal long and short axes, apical long axis, and apical 4-chamber views. The left ventricular end-diastolic diameter and left ventricular end-systolic diameter were determined, and the LVEF was calculated according to the modified Simpson method. The sonographers were blinded to the assignment of treatment and were not involved in the present study. Blood samples for the BNP measurement were obtained in the early morning after a 30-minute rest period, whereas the patient was in the supine position. An arterial blood gas sample was also collected at the time of each polysomnography. The protocol for the 6-minute walk test has been described elsewhere.25 The total distance walked in 6 minutes was measured and assessed. Sleepiness was subjectively evaluated using the Epworth sleepiness scale. QOL was assessed using the 36-item short form 36 (SF-36) questionnaire.26 The SF-36 consists of a 36-item questionnaire that evaluates 8 subscales.

Statistical Analysis

All values are shown as the means±SD, and categorical variables are expressed as numbers and percentages. The baseline characteristics were compared using Student t test for normally distributed data and the Mann–Whitney U test for nonnormally distributed data for continuous variables, whereas the χ2 test or Fisher’s exact test was used for categorical variables. Within- and between-group comparisons of measurements were carried out using paired and unpaired Student t tests for normally distributed data, and the Mann–Whitney U test and the Wilcoxon-signed rank test for nonnormally distributed data. The correlation between changes in LVEF and compliance was
assessed using Pearson correlation analysis. A P value <0.05 was considered statistically significant. All statistical analyses were performed using a statistical software package (SPSS version 11.0 for Windows; SPSS Inc, Chicago, Ill).

**Results**

**Patients’ Characteristics**

Of the 31 randomized patients, 16 were allocated to the ASV group and 15 to the CPAP group. Both groups were well matched for baseline characteristics (Table 1). The findings of the diagnostic sleep study are shown in Table 2. The mean AHI was similar in both groups and 50% of respiratory events were central. The representative respiratory events are shown in Figure 2.

One patient in the ASV group withdrew for personal reasons and failed to complete the trial, leaving 30 patients for complete analysis. No changes were made to patients’ medications during the study period. There were no changes in body mass index and no difference in the body mass index changes between the 2 groups (0.1 ± 1.0 kg/m² in the ASV group, 0.3 ± 1.3 kg/m² in the CPAP group; P=0.431). There were no changes in PaO₂ within each group and no difference in the PaO₂ changes between the 2 groups (0.7 Torr in the ASV group, 1.1 Torr in the CPAP group; P=0.931). On the other hand, a signifi-

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**Table 1. Baseline Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>ASV Group (n=16)</th>
<th>CPAP Group (n=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>56.9±14.3</td>
<td>56.5±12.6</td>
</tr>
<tr>
<td>Male gender</td>
<td>16 (100)</td>
<td>15 (100)</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>26.9±6.0</td>
<td>26.3±4.2</td>
</tr>
<tr>
<td>Epworth sleepiness scale</td>
<td>8.2±4.8</td>
<td>8.4±3.9</td>
</tr>
<tr>
<td>Cause of heart failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ischemic/nonischemic</td>
<td>5 (31.3)/11 (68.7)</td>
<td>4 (26.7)/11 (73.3)</td>
</tr>
<tr>
<td>NYHA class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>9 (56.2)</td>
<td>9 (60.0)</td>
</tr>
<tr>
<td>III</td>
<td>7 (43.8)</td>
<td>6 (40.0)</td>
</tr>
<tr>
<td>Left ventricular ejection fraction, %</td>
<td>35.7±12.9</td>
<td>36.0±8.1</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>7 (43.8)</td>
<td>5 (33.3)</td>
</tr>
<tr>
<td>ICD</td>
<td>2 (12.5)</td>
<td>2 (13.3)</td>
</tr>
<tr>
<td>PaO₂, Torr</td>
<td>83.5±10.9</td>
<td>83.0±8.2</td>
</tr>
<tr>
<td>PaCO₂, Torr</td>
<td>37.7±4.1</td>
<td>38.1±2.1</td>
</tr>
<tr>
<td>Medications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACE inhibitors/ARBs</td>
<td>15 (93.8)</td>
<td>14 (93.3)</td>
</tr>
<tr>
<td>β-blockers</td>
<td>14 (87.5)</td>
<td>15 (86.7)</td>
</tr>
<tr>
<td>Diuretics</td>
<td>12 (75.0)</td>
<td>11 (73.3)</td>
</tr>
<tr>
<td>Aldosterone blocker</td>
<td>8 (50.0)</td>
<td>7 (46.7)</td>
</tr>
<tr>
<td>Digoxin</td>
<td>1 (6.3)</td>
<td>1 (6.7)</td>
</tr>
<tr>
<td>Nitrates</td>
<td>4 (25.0)</td>
<td>3 (20.0)</td>
</tr>
</tbody>
</table>

Values are represented as n (%). NYHA indicates New York Heart association; ICD, implantable cardioverter defibrillator; ACE, angiotensin converting enzyme; ARB, angiotensin II receptor blocker.

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**Table 2. Findings of Sleep Study**

<table>
<thead>
<tr>
<th></th>
<th>ASV Group (N=16)</th>
<th>CPAP Group (N=15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TST, min</td>
<td>341.2±70.0</td>
<td>345.6±61.2</td>
</tr>
<tr>
<td>Apnea-hypopnea index, h</td>
<td>36.3±19.4</td>
<td>38.6±13.9</td>
</tr>
<tr>
<td>Central events, %</td>
<td>53.8±29.3</td>
<td>52.8±28.6</td>
</tr>
<tr>
<td>Lowest SO₂, %</td>
<td>80.6±4.7</td>
<td>80.2±7.7</td>
</tr>
<tr>
<td>TST spent with SO₂&lt;90%, %</td>
<td>22.7±30.4</td>
<td>23.0±25.6</td>
</tr>
<tr>
<td>Arousal index, h</td>
<td>40.7±20.4</td>
<td>38.7±13.7</td>
</tr>
<tr>
<td>Sleep stage % of TST</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slow wave sleep</td>
<td>9.5±8.6</td>
<td>9.9±5.1</td>
</tr>
<tr>
<td>Rapid eye movement sleep</td>
<td>10.7±7.3</td>
<td>11.7±4.4</td>
</tr>
</tbody>
</table>

TST indicates total sleep time; SO₂, oxyhemoglobin saturation.

**Figure 1.** A schema of the ASV titration algorithm. The EPAP was increased with a maximum of 10 cm H₂O if obstructive events were observed. Then, when the central apneas were not corrected, the automatic back-up rate was changed to the fixed back-up rate of 10 breaths per minute or more. After that, if continued periodic breathing (ie, CSR) was observed, maximal IPAP was raised by 2 cm H₂O. When EPAP was increased, the difference between minimal and maximal IPAP was maintained. IPAP min indicates minimal IPAP; IPAP max, maximal IPAP.
cant increase in the PaCO2 was observed only in the ASV group (from 37.7 Torr to 40.7 Torr; \(P<0.001\)), and a significantly greater increase in the PaCO2 was seen in the ASV group (3.2 Torr) than in the CPAP group (2.9 Torr; \(P=0.025\)).

Effects on SDB and Sleepiness
In both groups, treatment significantly reduced AHI (Figure 3A); however, the reduction of AHI was significantly greater in the ASV group than in the CPAP group (+3.2±2.9 Torr) than in the CPAP group (+1.1±2.0 Torr; \(P=0.025\)).

In the CPAP group, the mean provided pressure was 7.0±1.6 cm \(\cdot\) H\(_2\)O. On the other hand, in the ASV group, the mean provided IPAP and EPAP were 9.5±2.3 cm \(\cdot\) H\(_2\)O and 7.3±2.4 cm \(\cdot\) H\(_2\)O, respectively.

There were no statistically significant differences in the Epworth sleepiness scale changes between the 2 groups (3.2±3.4 in the ASV group and −2.7±3.5 in the CPAP group).

Cardiac Function
There were no significant differences in the blood pressure and heart rate changes between the 2 groups (Table 3). There were significant differences between the 2 groups in the increase in LVEF (Figure 4) and in the reduction...
of left ventricular end-systolic diameter and BNP (Table 3).

ASV significantly reduced urinary norepinephrine excretion, whereas CPAP did not. However, there were no significant differences in the reductions of urinary norepinephrine excretion between the 2 groups (Table 3).

The distance walked in 6 minutes increased significantly in the ASV group, whereas there was no such increase seen in the CPAP group. Thus, the increase in distance was significantly greater in the ASV group than in the CPAP group (Table 3).

**QOL Improvement**

After 3 months of treatment, the improvement in QOL was significantly greater with ASV than with CPAP (Figure 5), especially in vitality and the subscales associated with the physical component score.

**Compliance With Treatment**

During the study period, the compliance was 5.2±0.9 h/night with ASV and 4.4±1.1 h/night with CPAP group; compliance was significantly better with ASV than with CPAP.

A positive correlation between compliance and the increase in the LVEF was observed (Figure 6).
Discussion

The presence of SDB is associated with higher mortality among patients with CHF, and CPAP has been reported to be effective for both suppressing the abnormal breathing pattern and improving cardiac function in patients with CHF with either OSA or CSR-CSA. However, there are insufficient data with regards to reductions in morbidity and mortality when treating SDB with CPAP in patients with CHF. A post hoc analysis of the Canadian Continuous Positive Airway Pressure for Patients with Central Sleep Apnea and Heart Failure trial demonstrated that increases in transplant-free survival were greater in patients in whom CPAP sufficiently suppressed SDB than in the control group. This implies that CPAP treatment might improve long-term outcomes if SDB were sufficiently suppressed. On the other hand, poor compliance with CPAP is a major cause of concern. In the Canadian Continuous Positive Airway Pressure for Patients with Central Sleep Apnea and Heart Failure trial, CPAP use decreased after 12 months, and it was suggested that decreased CPAP operating time might cause unanticipated results among patients with predominant CSR-CSA. It was also reported that poor compliance with CPAP was associated with poor outcomes in patients with CHF with OSA. Therefore, ASV, which was reported as a more effective option for suppressing abnormal breathing with better compliance than CPAP, has been the focus of interest.

Based on this 3-month, randomized, parallel trial versus CPAP, flow-triggered ASV was superior for suppressing SDB, improving cardiac function, increasing the distance walked in 6 minutes, improving QOL, and compliance with the device. These results are comparable with those of other studies in which the efficacy of several positive airway pressure devices was investigated in patients with CHF with SDB, but they differ in the following 2 aspects: flow-triggered ASV was not used; and patients with coexisting OSA and CSR-CSA were not enrolled.

The algorithm of this flow-triggered ASV differs from another type of ASV, volume-triggered ASV, in terms of the target parameter for the automatic adaptation, setting options, and pressure range. In particular, the algorithm for flow-triggered ASV allows the application of CPAP (minimal IPAP=EPAP) and enables one to define the back-up rate individually, whereas the volume-triggered ASV device applies a minimal difference of 3 cm · H₂O between minimal IPAP and EPAP and has only an automatic back-up rate. Therefore, flow-triggered ASV is considered to be more practical for normalizing breathing in patients with coexisting OSA and CSR-CSA than volume-triggered ASV, which has been developed with a focus on patients with predominant CSR-CSA, even though no studies have compared these 2 devices. Because patients with pure CSR-CSA are rare in the current clinical setting, it might be important to focus on patients with coexisting OSA and CSR-CSA. In fact, the percentage of central events was lower in this study than in other studies in which patients with ≤70% or 80% of central events were enrolled. Therefore, it may be reasonable to presume that more patients can be regarded as candidates for treatment with this flow-triggered ASV.

In this study, SDB was sufficiently suppressed by flow-triggered ASV, whereas the efficacy of suppressing SDB in the CPAP group varied in each case. This varied response to CPAP is compatible with other studies. Moreover,
some patients who responded to CPAP on the night of the
titration study did not always sustain the response, whereas
the response to the ASV was consistently good throughout
the study period.

Compliance with the device was also of interest. Philippe
et al. reported that compliance with volume-triggered ASV
was greater than that with CPAP for 6 months after initiation
in a prospective, parallel, randomized, multicenter trial. As
well, in this study, compliance with flow-triggered ASV was
significantly greater than with CPAP throughout the 3
months. Such greater compliance with flow-triggered ASV
might be associated with (1) better comfort using the bilevel
pressure setting, which might be induced by providing
relatively lower pressure at expiration than at inspiration as
described in the other studies using a bilevel device or
volume-triggered ASV; (2) automatic adaptation of
pressure support, which may also be a source of better
comfort; and (3) sufficient and constant alleviation of SDB,
as shown in the other studies. Philippe et al. also showed that
improvements in the LVEF, and QOL, with this modality were
greater than with those with CPAP. Furthermore, Oldenburg et al.
showed that volume-triggered ASV improved cardiopulmonary
exercise testing parameters, in addition to other cardiac
parameters, at 6 months in an observational cohort. On the
other hand, data showing the efficacy of flow-triggered ASV
in patients with CHF and SDB are sparse, and to date, no
studies have investigated the efficacy of flow-triggered ASV
for improvements in cardiac function. To the best of our
knowledge, this study is the first to show the efficacy of
flow-triggered ASV for changes in several parameters of
cardiac function, such as LVEF, BNP level, and distance
walked in 6 minutes.

There was a significantly greater improvement in LVEF in the
ASV group (+9.1 ± 4.7%) than in the CPAP group. This
seems to be greater than that observed in other randomized
studies that investigated the improvement in LVEF with
several positive airway pressure devices in patients with CHF
with CSR-CSA. Reviewing previous studies, the
improvement in LVEF by positive airway pressure in patients
with CHF with predominant OSA was generally greater than
that with CPAP. Furthermore, Oldenburg et al. showed that
volume-triggered ASV improved cardiopulmonary
exercise testing parameters, in addition to other cardiac
parameters, at 6 months in an observational cohort. On the
other hand, data showing the efficacy of flow-triggered ASV
in patients with CHF and SDB are sparse, and to date, no
studies have investigated the efficacy of flow-triggered ASV
for improvements in cardiac function. To the best of our
knowledge, this study is the first to show the efficacy of
flow-triggered ASV for changes in several parameters of
cardiac function, such as LVEF, BNP level, and distance
walked in 6 minutes.

The following are all of the members of the Japanese trial to assess
the effect of adaptive servo-ventilation in chronic heart failure
ized trial assessing long-term outcomes including mortality,
in addition to ventricular remodeling, is imminent.

Our primary hypothesis was that, compared with CPAP,
flow-triggered ASV would result in better compliance with
the device and greater improvement in cardiac function (ie,
LVEF) in patients with CHF with coexisting OSA and
CSR-CSA. In addition to the better compliance, this study
showed significantly greater improvement in LVEF in the
flow-triggered ASV group than in the CPAP group. Furth-
more, there was a significant positive correlation between
LVEF improvement and compliance with the device. This
implies that better compliance with the device is an important
factor for improvement of cardiac function in patients with
CHF with SDB.

Another important finding of this study is that greater
improvement in QOL assessed using the SF-36 was obtained
with ASV than with CPAP. In particular, it has been reported
that the vitality score was treatment sensitive in the OSA. As
anticipated and intuitively, the improvement in vitality
was greater in the more effectively treated group, the ASV
group.

Limitations
This trial had several limitations. The first is the small
number of patients, all of whom were men. However, despite
this small number, significant superiorities in the improve-
ment of cardiac function, QOL, and compliance were noted in
the flow-triggered ASV group and were consistent with
previous results obtained with volume-triggered ASV. In
addition, the flow-triggered ASV group was greater in the more effectively treated group, the ASV

The second limitation is the lack of a group with neither
CPAP nor ASV. Given this, a further, randomized, prospec-
tive study that compares the changes in cardiac parameters of
3 groups (control, CPAP, and ASV groups) in patients with
CHF with coexisting OSA and CSR-CSA is warranted.

The third is that blinding was not possible. However, the
sonographers, the sleep specialists who scored the respiratory
events, and the statistician who analyzed the data were
completely blinded to the treatment assignment.

In conclusion, this showed that both CPAP and flow-
triggered ASV reduced AHI, but flow-triggered ASV resulted
in greater AHI reduction than CPAP, with consistent normal-
ization of AHI. Compliance was significantly better with
ASV than with CPAP. These differences may have contrib-
uted to the improvements in cardiac function and QOL in the
ASV group and also suggest that patients with CHF may
benefit more from treatment of coexisting OSA and CSR-
CSA with flow-triggered ASV than with CPAP.

Appendix
The following are all of the members of the Japanese trial to assess

Disclosures

References
CLINICAL PERSPECTIVE

In patients with chronic heart failure (CHF), the presence of sleep-disordered breathing, including either obstructive sleep apnea or Cheyne-Stokes respiration-central sleep apnea, is associated with a poor prognosis. A large-scale clinical trial showed that continuous positive airway pressure (CPAP) did not improve the prognosis of such patients with CHF, probably because of insufficient sleep-disordered breathing suppression. Recently, it was reported that adaptive servo-ventilation (ASV) can effectively treat sleep-disordered breathing. However, there are no specific data about the efficacy of flow-triggered ASV for cardiac function in patients with CHF with sleep-disordered breathing. The aim of this study was to compare the efficacy of flow-triggered ASV with CPAP in patients with CHF with coexisting obstructive sleep apnea and Cheyne-Stokes respiration-central sleep apnea. Thirty-one patients with CHF, defined as left ventricular ejection fraction ≤50% and New York Heart Association class ≥II, with coexisting obstructive sleep apnea and Cheyne-Stokes respiration-central sleep apnea, were randomly assigned to either CPAP or flow-triggered ASV. The suppression of respiratory events, changes in cardiac function, and compliance with the devices during the 3-month study period were compared. Although both devices decreased respiratory events, ASV more effectively suppressed respiratory events (ΔAHI [apnea-hypopnea index]: −35.4±19.5 with ASV, −23.2±12.0 with CPAP, P<0.05). Compliance was significantly greater with ASV than with CPAP (5.2±0.9 versus 4.4±1.1 h/night, P<0.05). The improvements in quality-of-life and LVEF were greater in the ASV group (ΔLVEF: +9.1±4.7% versus +1.9±10.9%). These results suggest that patients with coexisting obstructive sleep apnea and Cheyne-Stokes respiration-central sleep apnea may receive greater benefit from treatment with ASV than with CPAP.
Effect of Flow-Triggered Adaptive Servo-Ventilation Compared With Continuous Positive Airway Pressure in Patients With Chronic Heart Failure With Coexisting Obstructive Sleep Apnea and Cheyne-Stokes Respiration

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