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Methodology Article

Application of Telemonitoring to CPAP Titration

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ABSTRACT

The gold standard procedure for titration at Continuous Positive Airway Pressure (CPAP) initiation is inpatient split-night Polysom nography (PSG). However, titration using home-based monitoring technology should also be considered in terms of unfamiliarity of patients with CPAP and cost burden (or medical economy). Therefore, the application of telemonitoring to CPAP titration was reviewed using previous literature and our case study. We proposed a flowchart for CPAP titration with telemonitoring, which is currently used at our institution, and delayed Treatment-Emergent Central Sleep Apnea (TECSA) cases are presented. The application of telemonitoring to CPAP titration may be beneficial in real clinical world. In this case, the existence of TECSA is problematic. However, if we understand the characteristics of TECSA and consider the influence of dynamically changing loop gain and the presence of delayed TECSA, it may be more desirable to use a telemonitoring that can track daily Cheyne-Stokes Breathing% fluctuations.

Keywords: Telemonitoring; Obstructive sleep apnea; CPAP titration; Treatment-emergent Central Sleep Apnea (TECSA); Cheyne-Stokes Breathing (CSB)

Abbrevations: AASM: American Academy of Sleep Medicine; AHI: Apnea-Hypopnea Index; ASV: Adaptive Servo-Ventilation; BNP: Brain Natriuretic Peptide; CPAP: Continuous Positive Airway Pressure; CSB: Cheyne-Stokes Breathing; LG: Loop Gain; LL: Large Leak; PSG: Polysomnography; TECSA: Treatment-Emergent Central Sleep Apnea

INTRODUCTION

The gold standard procedure for titration at Continuous Positive Airway Pressure (CPAP) initiation is inpatient split-night Polysomnography (PSG). However, titration using home-based monitoring technology should also be considered in terms of unfamiliarity of patients with CPAP and cost burden (or medical economy). This option becomes relevant due to two key factors: The unfamiliarity of patients with CPAP and the cost burden associated with inpatient PSG. By utilizing home-based monitoring, patients can undergo titration in the comfort of their own homes while reducing the strain on medical resources and the financial burden for both patients and healthcare systems.

LITERATURE REVIEW

Carlier, et al. [1], reported that pressure modification based on telemonitoring data is useful for maintaining adherence for the first 6 months after CPAP initiation. In fact, the American Academy of Sleep Medicine (AASM) also provides a conditional recommendation that PAP treatment be initiated under telemonitoring [2]. A study has also shown the non-inferiority of telemonitoring compared with titration with PSG [3]. For telemonitoring, Treatment-Emergent Central Sleep Apnea (TECSA) is a problem. According to epidemiological studies on TECSA, the prevalence of TECSA varies from 2% to 20% at CPAP initiation, and a study has reported that TECSA could be resolved in several months after CPAP initiation [4]. TECSA has been suggested to be one of the factors responsible for the varying accuracy of the criteria for determining hypopnea events. However, in a prospective German study restricted to patients with normal Brain Natriuretic Peptide (BNP) levels, the prevalence of the events was extremely low at 0.56%, which might have also been affected by the difference in comorbidities among the patients [5]. Zeineddine, et al. [6], have presented the risk factors for TECSA.

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According to their table, the risk can be predicted to some extent from the patient characteristics, comorbidities, presence of mixed apnea during PSG, and other findings. Especially, titration study factors are important when the application of home-based monitoring is considered. The causes of TECSA at CPAP initiation are marked decreases in the arousal threshold due to unfamiliarity with CPAP and in $PaCO_2$ due to enhanced upper airway patency because of excessive pressure. It is thought that these factors increase the Loop Gain (LG) to induce Cheyne-Stokes Breathing (CSB). Based on this, we believe that patients can be managed by telemonitoring if the timing and amount of pressurization and leak at the onset of CSB are closely monitored [7]. We also consider home-based monitoring superior. Zeineddine, et al. [6], have also mentioned in their review that concomitant telemonitoring may eliminate the need for repeat PSG and that therapeutic strategies for TECSA should be individualized based on the underlying etiology and comorbidities [6].

Proposed clinical application of telemonitoring to CPAP titration

In our previous report Saito, et al. [8], have proposed a flow chart for the management of TECSA with telemonitoring, which was presented as supplemental material (Figure 1).

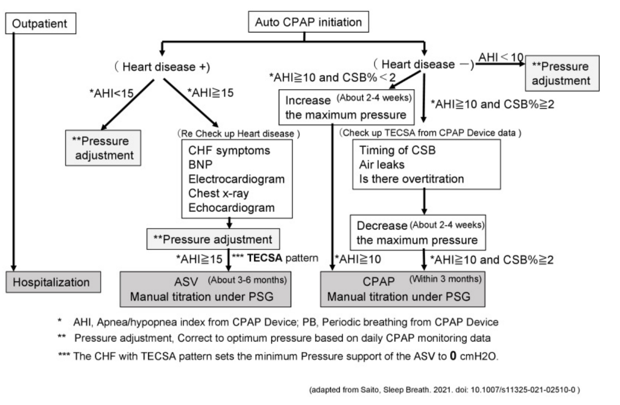

Figure 1: Flow chart of CPAP titration with telemonitoring.

METHODOLOGY

At our clinic, we first divided the patient group according to the presence or absence of heart disease. CPAP treatment is initiated in the Auto CPAP mode on an outpatient basis. When the treatment is initiated, the upper limit of pressure is set at a value estimated to be not excessive, according to the body weight of each patient. Within 1 week of treatment initiation, daily remote monitoring is initiated. The association between pressure variation and respiratory events, as well as the leak patterns, are closely monitored, in addition to the Apnea–Hypopnea Index (AHI) calculated using the CPAP device. The patient is re-examined at the outpatient clinic within 2-4 weeks after treatment initiation. If obstructive events persist (AHI ≥ 10, CSB % $_{Device}$<2%) after the set pressure upper limit is reached, we would raise the pressure limit further. When a patient exhibits CSB and an Large Leak (LL) with pressure reaching the upper limit or increasing despite an AHI ≥ 10, a CSB% $_{Device}$ ≥ 2%, and a decreased incidence of obstructive events, the patient is regarded to have TECSA. The pressure at the occurrence of CSB is assumed to be the break point, and the upper limit of the pressure is adjusted to be lower than this point. This adjustment leads to resolution of the TECSA pattern within 3 months in most patients without comorbid heart or cerebrovascular disease. When the TECSA pattern persists for 3 months, patients are admitted for manual CPAP titration under PSG. Meanwhile, patients suspected of having comorbid heart failure or other heart or cerebrovascular diseases and who provided consent undergo measurement of BNP level, electrocardiography, and echocardiography, according to different criteria (AHI ≥15 and CSB% $_{Device}$ >2%). The patients are then admitted for manual Adaptive Servo-Ventilation (ASV) titration under PSG within 3-6 months. Patients indicated for ASV are transitioned to ASV.

Figure 2 shows Case A appeared to be of delayed TECSA. The patient had no comorbidities or underlying diseases.

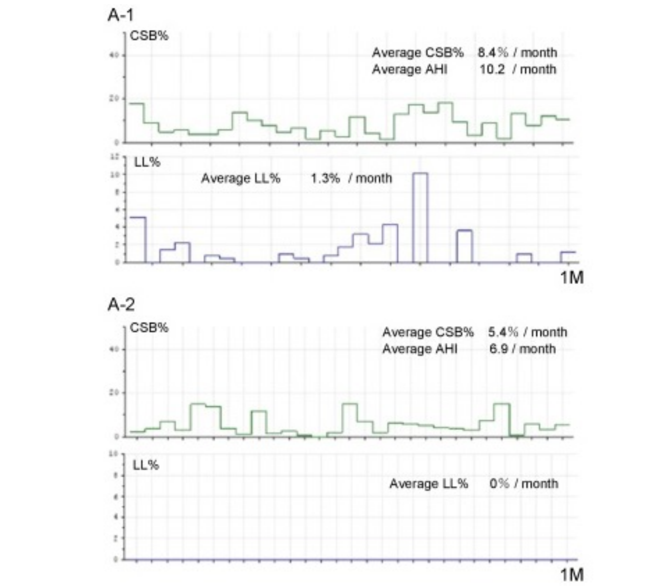

Figure 2: Fluctuations in CSB% and LL% over 1 month. **Note:** The changes in the CSB% during 1 month and leaks during the same period are presented for before manual titration (A-1) and after manual titration (A-2).

When approximately 1 year had passed after CPAP initiation, the telemonitoring data started showing an increased onset of CSB associated with leaks during the increases in pressure applied by the CPAP device. TECSA was suspected, and the pressure settings were changed. Since the CSB% continued to remain high afterward, inpatient PSG titration was performed. After the setting of CPAP was changed, the LLs disappeared, and the AHI improved from 10.2 to 6.9. However, CSB persists to date, and the patient is still receiving CPAP treatment. There are days when the AHI is ≥ 10. The patient's general condition is favorable. This patient originally had mixed apnea at the time of diagnostic PSG.

RESULTS AND DISCUSSION

A prospective cohort study has been conducted on CSB monitoring for TECSA, where the patients were examined by using telemonitoring data at 1 and 13 weeks after the initiation of Positive Airway Pressure (PAP) treatment. This study reported that TECSA occurred at 1 week in 3.5% of patients, of whom more than half experienced resolution of TECSA at 13 weeks. It also emphasized the importance of periodic and continuous telemonitoring because of the diverse types of TECSA [9].

Case A appeared to be of delayed TECSA. During follow-up, the patient developed neither comorbidities nor complications, and the body weight did not increase or decrease. However, the AHI, which was favorable soon after CPAP initiation, gradually worsened 1 year later. In this case, mixed apnea had originally been detected by PSG. Yamauchi, et al. [10], have described the presence of abnormal LG in mixed apnea-dominant cases. Thus, when mixed apnea is detected by PSG, we closely monitor the CSB% while keeping especially delayed TECSA in mind. Since TECSA also has features that show dynamic change, it is a phenomenon that clinically requires CSB monitoring.

CONCLUSION

The application of telemonitoring to CPAP titration may be beneficial in real clinical world. In this case, the existence of TECSA is problematic. However, if we understand the characteristics of TECSA and consider the influence of dynamically changing loop gain and the presence of delayed TECSA, it may be more desirable to use a telemonitoring that can track daily Cheyne-Stokes Breathing (CSB%) fluctuations.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

AVAILABILITY OF DATA AND MATERIAL

The datasets used and/or analyzed during this manuscript are available from the corresponding author on direct request.

ETHICAL APPROVAL

All patients provided written informed consent after we provided information regarding the study procedure.

INFORMED CONSENT

Written informed consent was obtained from participants.

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