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ORIGINAL ARTICLE

Can a Prediction Model Combining Self-Reported Symptoms, Sociodemographic and Clinical Features Serve as a Reliable First Screening Method for Sleep Apnea Syndrome in Patients With Stroke?

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Abstract

Objective: To determine whether a prediction model combining self-reported symptoms, sociodemographic and clinical parameters could serve as a reliable first screening method in a step-by-step diagnostic approach to sleep apnea syndrome (SAS) in stroke rehabilitation.

Design: Retrospective study.

Setting: Rehabilitation center.

Participants: Consecutive sample of patients with stroke (N=620) admitted between May 2007 and July 2012. Of these, 533 patients underwent SAS screening. In total, 438 patients met the inclusion and exclusion criteria.

Interventions: Not applicable.

Main Outcome Measures: We administered an SAS questionnaire consisting of self-reported symptoms and sociodemographic and clinical parameters. We performed nocturnal oximetry to determine the oxygen desaturation index (ODI). We classified patients with an ODI $\geq$15 as having a high likelihood of SAS. We built a prediction model using backward multivariate logistic regression and evaluated diagnostic accuracy using receiver operating characteristic analysis. We calculated sensitivity, specificity, and predictive values for different probability cutoffs.

Results: Thirty-one percent of patients had a high likelihood of SAS. The prediction model consisted of the following variables: sex, age, body mass index, and self-reported apneas and falling asleep during daytime. The diagnostic accuracy was .76. Using a low probability cutoff (0.1), the model was very sensitive (95%) but not specific (21%). At a high cutoff (0.6), the specificity increased to 97%, but the sensitivity dropped to 24%. A cutoff of 0.3 yielded almost equal sensitivity and specificity of 72% and 69%, respectively. Depending on the cutoff, positive predictive values ranged from 35% to 75%.

Conclusions: The prediction model shows acceptable diagnostic accuracy for a high likelihood of SAS. Therefore, we conclude that the prediction model can serve as a reasonable first screening method in a stepped diagnostic approach to SAS in stroke rehabilitation.

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Sleep apnea syndrome (SAS) is a highly prevalent sleep disorder in patients with stroke and is known to contribute to poor functional recovery, increased risk of recurrent stroke, and poststroke mortality.[1-3]

Standard evaluation of SAS in stroke rehabilitation settings is limited, despite its high prevalence and serious consequences.[4] When SAS is suspected, clinical SAS guidelines recommend

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attended overnight polysomnography or multichannel polygraphy.[5] In stroke rehabilitation, however, these approaches are often not feasible because of limited access, high costs, and practical constraints. Hence, we propose a step-by-step diagnostic approach to SAS in which patients with stroke receive only the level of SAS screening they need, beginning with simple, less costly methods followed by a full sleep study, if required. This approach asks for easily administered and reliable screening instruments for the detection of patients with a high likelihood of SAS. In this context, we recently performed a study to evaluate the diagnostic value of nocturnal oximetry screening in patients with stroke. We found that nocturnal oximetry was highly accurate for predicting SAS in the stroke population with excellent diagnostic accuracy (93%) and positive and negative predictive values of 83% and 100%, respectively.[6]

Another even more simple screening method is the use of self-report SAS questionnaires. One of the most frequently administered SAS questionnaires in general sleep clinics is the Berlin questionnaire (BQ).[7] The BQ asks about known risk factors for sleep apnea, namely snoring behavior, sleepiness, fatigue, and the presence of hypertension and obesity. Although the BQ is well-validated in general sleep clinics,[7] recent validation studies in the stroke population were disappointing; they found that the BQ could not adequately discriminate between patients with and without SAS.[4,8,9]

Because the BQ is not able to accurately predict SAS in patients with stroke and nocturnal oximetry is currently not yet widely available in stroke rehabilitation settings, it is of interest to develop an adequate and easily accessible SAS screening tool that could be administered as the first step in the detection of SAS. The BQ contains a selection of SAS-related symptoms, but it does not ask about daytime consequences (eg, concentration loss, morning headaches, depressed mood, irritability). Moreover, the BQ does not include important sociodemographic and clinical risk factors (eg, age, sex, smoking, comorbidities, medication use).[10] The primary aim of the present study was to determine whether a predictive model based on a combination of self-reported symptoms, sociodemographic variables, and clinical parameters could serve as a reliable screening method for the stepped diagnosis of SAS.

Methods

Participants

We conducted a retrospective study of a consecutive cohort of 620 patients with stroke who were admitted to the stroke rehabilitation unit of Heliomare, a rehabilitation center in The Netherlands, between May 2007 and July 2012. All patients who were referred to the stroke rehabilitation unit were able to participate in active multidisciplinary stroke rehabilitation and had a good prognosis for return to home. Patients were excluded from screening if they were <18 years or if they had a previous diagnosis and treatment of SAS. In total, 533 patients with stroke agreed to SAS screening. Patients were included in our study when diagnosis of stroke was confirmed by a neurologist based on a history of sudden onset of a neurologic deficit lasting >24 hours and a brain lesion compatible with the neurologic deficit on computerized tomography or magnetic resonance imaging. Patients were excluded if the SAS questionnaire was not completed (n=28) or nocturnal oximetry was not performed (n=55) (eg, because of severe aphasia, confusion, unwillingness to participate). In total, 438 patients met the inclusion and exclusion criteria and were included in the further analysis. The ethics committee of the institutional review board approved the study protocol.

List of abbreviations:

BMI	**body mass index**
BQ	**Berlin questionnaire**
CI	**confidence interval**
ODI	**oxygen desaturation index**
ROC	**receiver operating characteristic**
SAS	**sleep apnea syndrome**

Procedure and measurements

Within 4 weeks of admission to the stroke rehabilitation unit, an SAS questionnaire was administered in a face-to-face interview with a trained nurse. The SAS questionnaire consists of 3 categories: sociodemographic characteristics, self-reported symptoms, and clinical characteristics. Questions on sociodemographic characteristics were composed of sex, age, partner status, and smoking. The self-reported symptoms assessed in the questionnaire are based on the features of SAS described in the International Classification of Sleep Disorders by the American Academy of Sleep Medicine[11] and include questions on snoring, apneas, daytime sleepiness, fatigue, falling asleep during the day, not waking up refreshed, concentration loss, morning headaches, restless legs, mood disturbances, and irritability. For each question, the patient is asked to report if the symptom was present (yes or no). The nurse extracted clinical data from the medical records, including stroke subtype, stroke localization, first or recurrent stroke, comorbidities (hypertension, diabetes, thyroid disease, pulmonary and cardiac comorbidities), body mass index (BMI), and blood pressure. Within 8 weeks of admission, nocturnal oximetry was conducted to determine the oxygen desaturation index (ODI). Validation of nocturnal oximetry against multichannel polygraphy showed that the ODI is a close estimate of the apnea-hypopnea index in patients with stroke, with excellent diagnostic accuracy of 93% for the detection of SAS in stroke rehabilitation.[6] The pulse oximeter[a] was preprogrammed to collect data between 11 PM and 7 AM. Recordings were analyzed automatically. The ODI was defined as the mean number of desaturations of ≥3% from baseline per hour. In accordance with the guideline for diagnosis of SAS (apnea-hypopnea index ≥15), we classified patients with an ODI of ≥15 as having a high likelihood of SAS.

Statistical analysis

We used descriptive statistics to characterize the patient sample. We calculated group differences between patients with ODI <15 and ODI ≥15 using chi-square or Student *t* tests. The prediction model was developed in 2 consecutive steps. Because of the large number of possible predictive variables in relation with the sample size, the first step was to select potential predictors for a high likelihood of SAS (ODI ≥15) using univariable regression. We selected the variables that were univariably associated with a high likelihood of SAS with a probability value of <.20. This way we reduced the number of variables without discarding potential important predictors. All variables were checked for collinearity. In the second step, a multivariate analysis was performed using