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Original Article

A screening tool for obstructive sleep apnea in cerebrovascular patients

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ABSTRACT

Background: A majority of stroke patients suffer from obstructive sleep apnea (OSA), which can go unrecognized as the current OSA screens do not perform well in stroke patients. The objective of this study is to modify the existing OSA screening tools for use in stroke patients.
Methods: The cohort study consisted of patients who completed the validated OSA STOP screen and underwent polysomnography within one year. Six prediction models were created and sensitivity and specificity of various cut points were calculated.
Results: There were 208 patients with mean age of 55.4 years; 61.0% had sleep apnea. Models with the highest c-statistics included the STOP items plus BMI, age, and sex (STOP–BAG). Addition of neck circumference and other variables did not significantly improve the models.

The STOP–BAG$_2$ model, using continuous variables, had a greater sensitivity of 0.94 (95% CI 0.89–0.98) and specificity 0.60 (95% CI 0.49–0.71) compared to the STOP–BAG model, which used dichotomous variables, and had a sensitivity of 0.91 (95% CI 0.85–0.96) and specificity of 0.48 (95% CI 0.37–0.60).
Conclusions: The STOP–BAG screen can be used to identify cerebrovascular patients at an increased risk of OSA. The use of continuous variables (STOP–BAG$_2$) is preferable if automated score calculation is available. It can improve the efficiency of evaluation for OSA and lead to improved outcomes of patients with cerebrovascular disease.

1. Introduction

Obstructive sleep apnea (OSA) occurs in over half of patients with stroke/transient ischemic attack [1] and is associated with worse functional status and increased mortality after stroke [2]. Treatment of OSA can improve outcomes [3] and lower recurrent stroke risk; however, OSA is often undiagnosed. Sleep apnea is diagnosed using polysomnography (PSG) or portable devices that can be used in home sleep testing. Polysomonograms are costly, inconvenient, and necessitate the presence of a caregiver. Home sleep testing is much less expensive but may not be appropriate or feasible for patients with certain comorbidities or inability to ensure the integrity of the sensors during a night of sleep at home [4]. The ability to systematically identify cerebrovascular patients at high risk for OSA would allow more efficient diagnosis and treatment of OSA. However, current OSA screens do not perform well in stroke patients [4–7]. This is likely because clinical symptoms suggestive of sleep apnea in the general population do not distinguish between stroke patients with and without apnea. For instance, over a quarter of patients with sleep apnea do not snore, while over 50% of stroke patients without sleep apnea do snore [1]. Epworth sleepiness scale (ESS) scores are often normal in stroke patients with sleep apnea [3]. The recent American Stroke Association secondary stroke prevention guidelines cite the lack of adequate screening tools for sleep apnea in stroke patients and so recommend consideration of performing a sleep study in patients with prior stroke or transient ischemic attack [8]. The objective of this study is to modify the existing OSA screening tools using variables easy to obtain during ambulatory visits of patients with cerebrovascular disease to better understand the operating framework of commonly used sleep apnea screening items based on the STOP-BANG [9] instrument in a stroke population.

2. Methods

2.1. Design, setting, and subjects

This retrospective study included patients from the ambulatory Cerebrovascular Clinic at Cleveland Clinic between January 2011 and December 2012 who completed the self-administered STOP [9]

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Table 1
STOP–BANG Screening Tool.

Item	Description
STOP	
Snoring	*"Do you snore loudly (louder than talking or loud enough to be heard through closed doors?"*
Tiredness during daytime	*"Do you often feel tired, fatigued, or sleepy during daytime?"*
Stop breathing during sleep	*"Has anyone observed you stop breathing during your sleep?"*
High blood pressure	*"Do you have or are you being treated for high blood pressure?"*
BANG	
Body mass index	Body mass index >35 kg/m^2
Age	Age >50 years
Neck circumference	Neck circumference >40 cm
Gender	Male sex

STOP–BANG questionnaire reproduced, with permission from Wolters Kluwer: Chung F et al. STOP questionnaire: A tool to screen patients for obstructive sleep apnea. *Anesthesiology*. 2008;108:812-821 [9].

screen during their visit and underwent PSG within one year. Patients observed in the Cerebrovascular Clinic had a mix of cerebrovascular diagnoses such as ischemic stroke, intracerebral hemorrhage, and carotid occlusion. The STOP screen is a commonly used self-administered OSA screening tool comprising yes/no questions on snoring, tiredness, fatigue, or sleepiness during the daytime, observed apnea during sleep, and high blood pressure [9]. The STOP screen data were collected through the Cleveland Clinic Knowledge Program,© an electronic platform for patient-reported data collection [10]. Patients complete questionnaires using an electronic tablet or kiosk in the clinic waiting area or at home via the internet using an interactive patient health record (MyChart, Epic Systems). A diagnosis of OSA was made via PSG performed in the Cleveland Clinic Sleep Disorders Center. OSA was defined as an obstructive apnea–hypopnea index (AHI) ≥ 10 on PSG [11]. Hypopnea scoring required a >3% desaturation or arousal. This cutoff was chosen as it is typically used to make decisions on the initiation of treatment. The study was approved by the Cleveland Clinic Institutional Review Board.

2.2. Statistical analysis

The summary statistics of demographic and clinical characteristics were compared for patients included in the study cohort and those excluded because they did not undergo PSG. Within the study cohort, summary statistics were compared for patients with and without OSA.

Variables in the predicted models consisted of those in the STOP–BANG screen [9] (Table 1) and additional predictor variables based upon literature review. The STOP variables were self-reported by the patient. Neck circumference (NC) and body mass index (BMI) were taken from the data recorded at the time of the sleep study. All other variables were electronically extracted from the electronic health record (EHR; Epic™, Epic Systems, Verona, Wisconsin).

2.3. Prediction models

Six prediction models were created using logistic regression, where the dependent variable was the presence of OSA. The predictor variables for each model are given below:

1. STOP: STOP score (possible values 0–4)
2. STOP–BANG: STOP score + additional points if BMI >35 kg/m^2, age >50 years, NC >40 cm, or male sex (possible values 0–8)
3. STOP–BAG: same as STOP–BANG but without NC (possible values 0–7)
4. STOP–BANG$_2$: STOP score plus sex and continuous variables BMI, age, and NC
5. STOP–BAG$_2$: STOP score plus sex and continuous variables BMI and age
6. STOP–BAG$_2$+: same as STOP–BAG$_2$ score plus history of coronary artery disease (yes/no), self-reported average hours of sleep per night, smoker status (Never, Former, Current).

The models were created and validated using bootstrap methods in R, version 3.0 [12]. Validation was done using bootstrap methods with 200 iterations. Multiple imputation was used to handle missing data.

Receiver operating characteristic (ROC) curves were created and c-statistics or areas under the ROC curve (AUC) were compared. In order to compute the sensitivity and specificity for the STOP and STOP–BANG models, we used the standard values of 2 and 3 [9]. We also used a value of 3 for the STOP–BAG. For each of the STOP–BANG$_2$, STOP–BAG$_2$, and STOP–BAG$_2$+ models, we found the predicted probability generated by the model that resulted in the sensitivity closest to the sensitivity produced by the STOP–BANG model. Exact binomial methods were used to obtain confidence intervals for the sensitivities and specificities. McNemar's test was used to compare specificities. Holm's method was used to adjust for multiple comparisons.

2.4. Subgroup analyses

We examined the sensitivities and specificities for each model for the subgroup of patients with a visit diagnosis of ischemic stroke. Because of small sample sizes, we did not investigate the diagnostic performance in other cerebrovascular diagnostic categories. In order to investigate whether diagnostic performance varied by gender, we computed sensitivity and specificity in men and women separately, using the same cut points as for the original cohort. We also examined how results changed when the AHI cutoff for diagnosis of OSA was set to 5, 20, and 30.

3. Results

There were 208 patients in the study cohort with mean age 55.4 years, of whom 61.0% were diagnosed with sleep apnea based on an AHI ≥10. Cerebrovascular providers referred patients for testing in 35.6% (74/208) of cases. The median time from stroke to PSG was 235 days (interquartile range 102–479) for the 111 patients with visit diagnosis of ischemic stroke or intracerebral hemorrhage. Patients with OSA were generally older, more likely to be men, more likely to endorse the STOP items except for "tiredness/fatigue/sleepiness during the daytime," had higher BMI, larger NC, and shorter total sleep time (Table 2).

Patients in the study cohort were much more likely to endorse each of the four questions on the STOP questionnaire ($P < 0.0001$ for all) compared to those who completed the questionnaire but did not have a PSG within 1 year (Table 3). BMIs of study patients were significantly higher than in those with STOP score who did not undergo PSG ($p < 0.0001$; Table 3).

OSA prediction models with the highest c-statistics included the STOP screen plus the variables BMI, age, and gender (STOP–BAG) as shown in Fig. 1. STOP–BANG had slightly better sensitivities to STOP–BANG with similar specificities. However, the addition of NC did not significantly improve the models; there were no significant differences between c-statistics for the STOP–BANG and STOP–BAG models (Holm-adjusted p-value = 0.0734) or between the STOP–BANG$_2$ and STOP–BAG$_2$ models t (Holm-adjusted p-value = 0.0890).

The models using continuous BMI, age, and NC (STOP–BANG$_2$ and STOP–BAG$_2$ models) outperformed those using dichotomized versions (STOP–BANG and STOP–BAG models). The addition of average