High-Resolution Pulse Oximetry (HRPO): A Cost-Effective Tool in Screening for Obstructive Sleep Apnea (OSA) in Acute Stroke and Predicting Outcome

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Introduction: Obstructive sleep apnea (OSA) is a well-known risk factor for stroke. This is attributed to multiple mechanisms such as endothelial dysfunction, atrial fibrillation, hypertension, and comorbid obesity. STOP questionnaire alone is unreliable to diagnose OSA and in-hospital sleep study is costly and can be technically challenging. We used high-resolution pulse oximetry (HRPO) to test the feasibility of screening for OSA and predicting outcome. *Methods:* Data from 115 stroke patients who underwent HRPO was collected including Oxygen desaturation index (ODI) <4%, pulse rate, arterial oxygen saturation (SaO_2), and time spent at SaO_2 saturation <88%. We also collected data on various confounders. The outcomes measured were NIHSS (National Institutes of Health Stroke Scale), mRS (modified Rankin Score) on discharge, and discharge disposition. *Results:* Overall 115 patients with valid HRPO data were included in the study. Mean age was 64±12 years with 68% white, 22% black, and 10% Hispanic population. Of this cohort of 115 patients, 56% were males. Of the subjects enrolled 22 had atrial fibrillation, 27 had type 2 diabetes, 7 had resistant hypertension, and 7 had patient foramen ovale. Of the 115 patients, 75 patients were found to have ODI of >10 and the mean ODI was 29±30. The NIHSS on admission was 6.14±6.93 and on discharge was 4.46±4.59, mRS on discharge was 1.70±1.67 with 52% being discharged home, 43% to rehab, 2% nursing home, and 3% to long-term acute care facility. In this study, we show a strong association between atrial fibrillation and increasing ODI ($P<.001$, OR 1.01, CI 1.00-1.03). In addition, our study also shows an association between discharges outcome of rehab (more deficits leading to higher disability) versus discharge to home (lesser deficits) if ODI was ≤10 ($P = 0.005$, OR 3.76, CI 1.49-9.52). *Conclusions:* Our study showed that there is a significant burden of OSA in acute stroke patients. ODI emerged as a predictor of atrial fibrillation and discharge disposition in our study. HRPO may be a cost-effective tool to screen and evaluate for OSA in acute stroke patients.

Key words: OSA—Stroke—Atrial fibrillation—HRPO—ODI

Obstructive sleep apnea (OSA) has been shown to be an independent risk factor for stroke.[1] It is postulated that OSA increases the risk of stroke by affecting the autonomic nervous system, nondipping blood pressure during sleep, increased daytime blood pressure, and increased prevalence of atrial fibrillation (AF).[2] Recent

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studies have suggested that it is the nocturnal oxygen desaturations rather than apnea-hypopnea index (AHI) that is a predictor of AF in ischemic strokes.[3,4] Up to 35.5% of strokes happen during sleep suggesting a role of hypoxia and hemodynamic responses due to OSA.[5] Although screening questionnaires are available for atypical presentation of OSA in stroke, they are only moderately sensitive.[6] Polysomnography can be challenging to perform in the stroke unit due to fragmented sleep. High-resolution pulse oximetry (HRPO) recording using photoplethysmography signal has been shown to be sensitive and specific for detecting OSA in stroke and other populations like congestive heart failure.[7,9] Prior studies have shown that the severity of OSA predicts stroke outcomes.[8]

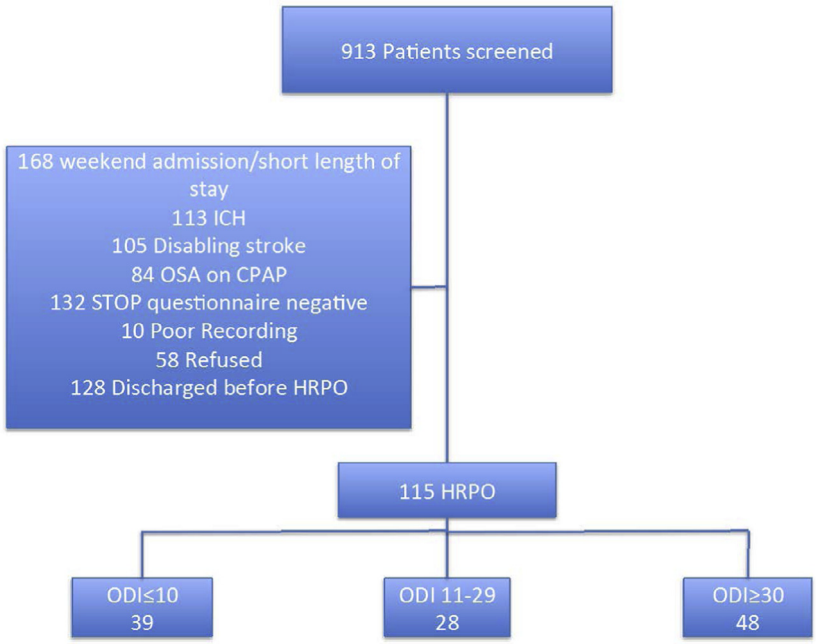
The authors hypothesized that the oxygen desaturation index (ODI) as determined by HRPO may effectively screen patients with OSA and predict outcomes of acute ischemic stroke.

Materials and Methods

The study was performed at a single center with the approval of the local Institutional Review Board. Patients were recruited from September 2015 to June 2016. Inclusion criteria included patients older than 18 years of age admitted to the stroke unit with a diagnosis of ischemic stroke. Exclusion criteria included patients with diagnoses of transient ischemic attack (TIA), devastating strokes (modified Rankin Score, mRS $\geq$ 4), intracranial hemorrhage (ICH), and patients already with diagnosed OSA and compliant with CPAP at home. All patients enrolled in the study receive a STOP questionnaire (S-Snoring, T-Tiredness, O-Observed, P-Pressure). Patients who scored $\geq$2 on the STOP questionnaire received a HRPO. A minimum of 2 hours of good quality recording was considered optimal for analysis. If less than 2 hours of data were recorded, the study was repeated the next night or data was not used in our analysis. During HRPO, the lowest and mean oxygen saturation, lowest and mean heart rate, ODI 4% (defined as number of times per hour oxygen saturation drop below 88% by 4%), and the total time spent during recording below 88%(TST 88) were obtained for each patient. OSA was defined as ODI > 10. Also, each patient chart was reviewed for the following: resistant hypertension (resistant HTN), AF, patient foramen ovale (PFO), diabetes mellitus (DM), chronic kidney disease (CKD), stroke subtype (lacunar, large vessel, and embolic), stroke location (cortical, subcortical, posterior, and mixed), left ventricular ejection fraction (LVEF), hemoglobin A1c, discharge disposition, mRS, and National Institutes of Health Stroke Scale (NIHSS) (Flowchart 1).

Statistical Analysis

Statistical analysis was performed using IBM SPSS 24. Data were examined both as continuous variables and dichotomized based on visual examination of the distributions per group. The variables underwent a preliminary bivariate screening with a chi-square test, Fisher exact test, or linear regression. Because of multiple testing issues, *P*-values close to .05 were treated as potential false positives. Nonparametric tests (Spearman rank correlation and Mann-Whitney *U* test) were used to confirm statistical significance. These tests were followed by



Flowchart 1. *Screening with exclusions and breakdown of HRPO based on ODI severity.*