Recognition and Treatment of Sleep-Disordered Breathing in Obese Hospitalized Patients May Improve Survival. The HoSMed Database

Recognition and treatment of sleep disordered breathing in obese hospitalized patients may improve survival. The HoSMed database.

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Abstract

Rationale: Sleep disordered breathing (SDB) is a common sleep disorder with a high prevalence in general population. Recent studies have shown that hospitalized obese patients have a high likelihood of unrecognized SDB. However, no systematic large study has so far evaluated the outcomes of a screening program to identify these patients. This study provides demographic, clinical and outcome data from a screening program at a tertiary care academic center.

Methods: Subjects were 5062 patients screened from March 2013 to July 2016. Of these, 1410 underwent in-hospital overnight high-resolution pulse oximetry (HRPO) and 680 underwent polysomnography post discharge. Patients placed on positive airway therapy (PAP) were followed in an ambulatory setting and mortality data were compared between compliant versus non-compliant patients.

Results: The mean age was 60.7 years (SD 15.2), mean BMI was 34.8 kg/m^2(SD 8.3) with 2477 (49.0%) males. In the entire cohort, 3336 were found to be at high risk based on screening with a STOP or STOP-BANG questionnaire. Of the 1410 high-risk patients who underwent HRPO, 1092 were SDB positive (ODI $\geq$ 5) and 680 high-risk patients

underwent polysomnography. In this latter group, 585 (87%) were found to have SDB (AHI>5). A receiver operator curve (ROC) for oxygen desaturation index (ODI) derived from HRPO plotted against apnea hyponea index (AHI) from polysomnography showed an area under the curve of 0.83 for an ODI of > 5. Patients who were adherent to PAP therapy in the first three months had improved survival over a mean follow-up of 609 days compared to those who were non-adherent (p=0.01).

Conclusion: This large database of hospitalized patients confirms a high prevalence of undetected SDB in this population. Our screening protocol of a clinical questionnaire combined with HRPO testing is effective in identifying SDB and long-term follow up of those compliant with treatment reveals a survival benefit.

Keywords: Obesity, Sleep apnea, Heart Failure, Polysomnography.

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Introduction

Sleep Disordered breathing (SDB) is a modern world epidemic with an estimated prevalence of 26%[1]. It is implicated as a risk factor in the development of numerous cardiovascular conditions including congestive heart failure, hypertension, atrial fibrillation and stroke[2]. Furthermore, several large observational trials have identified SDB as a risk factor for premature mortality[3-5]. Despite extensive evidence of its detrimental impact on health, SDB remains under-diagnosed and under-treated[6]. Moreover, delayed diagnosis of SDB may be adding to the burden of complications from other medical conditions such as diabetes[7] and renal failure[8] . Thus, efforts to more quickly diagnose and treat persons with SDB have the potential to reduce negative outcomes[9].

Recent efforts to perform SDB screening and treatment in hospitalized patients have been encouraging. Studies by ourselves and others have shown that early diagnosis of SDB and intervention in hospitalized patients resulted in a reduction in 30-day and 6 month readmissions in patients admitted for acute heart failure and chronic obstructive pulmonary disease (COPD) exacerbation[10-12]. In this analysis we extend our previous findings to include a substantially larger number of patients to not only confirm the high prevalence of unrecognized SDB in hospitalized patients, but also to determine its impact on survival of patients after early intervention with positive airway pressure (PAP) therapy.

Methodology

Between March 2013 to July 2016, 5062 patients admitted to the cardiology, internal medicine, and family practice services with a body mass index (BMI, weight [kg]/height, [m^2]) ≥ 30 were screened for SDB with the STOP (snoring, tiredness during daytime, observed apnea, high blood pressure). In addition, patients admitted to the advanced heart failure service with the diagnosis of CHF were screened using the full STOP-BANG questionnaire[13]. The questionnaires were administered by a respiratory therapist. The STOP and STOP-BANG questionnaires are easy to use succinct tools which can be administered by health care professionals with a minimal increase in work burden. The STOP-BANG was administered to cardiology service patients since there is evidence that patients with heart failure do not always exhibit excessive daytime sleepiness/tiredness[14]. The STOP-BANG adds objective measures of BMI, neck collar size (> 40 cm), gender (males are at higher risk) and age (>50 years). The admitting team was notified if the STOP/ STOP-BANG questionnaire was positive (answering yes to two or more items in STOP and 3 or more in STOP-BANG) who then contacted a board-certified pulmonary sleep medicine physician (inpatient consult service) to determine whether a follow-up consultation was necessary (Figure 1). A consultation by a board-certified sleep specialist determined if the patient required a nocturnal high resolution plethysmography (HRPO). The contra-indications for in-hospital HRPO included oxygen

requirement > 30%, severe pain, insomnia, altered mental status, anticipated disruption during sleep (imaging/tests or surgeries). Upon high clinical suspicion of SDB (defined according to the Adult OSA Task Force of the American Academy of Sleep Medicine[15] [AASM]), patients were advised to undergo a post-discharge confirmatory polysomnogram (PSG). Patients admitted during the weekends were not included in the study. Using the hospital electronic medical records and patients' outpatient sleep center charts, a database of the STOP or STOP-BANG results, demographic and relevant clinical information was compiled and stored in REDCap (https://projectredcap.org/). Out of 5062 patients included in the final database, 1161 patients have been included in prior publications[9,11,12,16,17]. The Thomas Jefferson University Institutional Review Board approved the study.

Polysomnogram evaluations were conducted at an AASM accredited sleep center, and included an electrocardiograph, electroencephalograph, continuous oronasal airflow recording (with a thermistor and a pressure transducer), recording of chest wall and abdomen movement (using respiratory inductive plethysmography belts), transcutaneous oximetry, and chin electromyography (Comet AS 40 PSG, Grass Technologies; Warwick, RI, USA). Sleep was staged manually according to AASM scoring guidelines by a registered PSG technologist. The apnea-hypopnea index (AHI) was calculated as the number of apneas plus hypopneas per hour of total sleep time, with hypopneas defined using a desaturation criterion of 4%. A single, board-certified sleep physician interpreted the polysomnograms. The high resolution pulse oximetry was performed

using a Masimo RAD-57 machine (Irvine, CA) standardized to an average time of 3 sec and oxygen desaturation index cutoff of 4%, which is consistent with AASM recommendations[18]. Patients who were confirmed to have SDB were started on PAP therapy and followed for a mean of 609 days and median of 570 days to determine their adherence with PAP therapy and vital status.

Statistical analysis

Summary statistics of all patients, SDB patients adherent to PAP therapy and SDB patients non-adherent to PAP therapy were calculated. Compliance information for the first 4-6 weeks of PAP therapy was downloaded and reviewed during a patient's first follow up visit to the sleep center or was obtained from the durable medical equipment provider. Adherence was defined as use of the PAP device for 4 hours or more per night for $\geq$70% of the nights. Tabulations and percentages were calculated for categorical variables. Means, medians, standard deviations and ranges were calculated for continuous variables. Multivariate logistic regression was used to determine significant predictors of SDB.

Using AHI $\geq$ 5 events per hour as the diagnostic criteria for SDB, we constructed a receiver-operator curve to describe the accuracy of correctly identifying SDB with the ODI. The area under the curve (AUC) was calculated. Additionally, a relative Bland-Altman plot was constructed which compared the ratio of ODI to AHI. As discussed in

Bland-Altman (1986), the relative Bland-Altman plot (using log-transformed data) is preferable when the data show fanning, or higher variability with increased mean values.

Finally, the Kaplan-Meier survival curves for SDB patients' adherent to therapy and SDB patients non-adherent to therapy were constructed and compared with a Log-rank test. To adjust for potential confounding variables because this is an observational study, a propensity score analysis was conducted. Specifically, propensity scores for each patient were calculated with a logistic regression model that predicted compliance using age, BMI, race, heart failure, asthma/COPD, and diuretic use. Other demographic variables such as AHI, other medication use, and other comorbidities were considered but not included in the model due to their low association with compliance. Finally, an inverse propensity score weighted Log-Rank survival analysis was conducted.

Results

Data from a total of 5062 patients screened from March 2013 to July 2016 were analyzed. Overall, the mean age was 60.7 years (SD 15.2), mean BMI was 34.8 kg/m^2 (SD 8.3) with 2477 (49.0%) males. Co-morbidities included 882 (17.4%) patients with heart failure (CHF), 971 (19.2%) with asthma/COPD, 1798 (35.5%) with coronary artery disease, 1849 (36.5%) with type-2 diabetes, 3181 (62.9%) with hypertension (HTN), 866 (17.1%) with chronic renal failure (CRF) and 905 (17.9%) with atrial fibrillation. (Table 1) Compliant patients were older (p-value<0.0001), more likely to be white (p-

value<0.0001), and less likely to have asthma/COPD (p-value=0.02) and atrial fibrillation (p-value=0.04).

As shown in Figure 1, of the 5062 screened patients, 3336 (66%) tested positive for SDB by the STOP/STOP BANG questionnaire. Of these 3336 positive screens, 1604 patients were evaluated by the hospital inpatient service led by a board certified sleep physician. Of these consults, 1410 HRPO's were performed with 1092 revealing an ODI $\geq$ 5. Of the 680 PSG's performed post discharge, 592/680 (87%) were diagnosed with SDB (AHI$\geq$5). The mean AHI for patients undergoing PSG was 30.0 (30.3) and mean ODI in patients who underwent HRPO was 21.4 (21.4). Assuming that the positive PSG confirmation rate of 87% can be applied to the entire cohort of those patients who had an ODI $\geq$ 5, the estimated prevalence of SDB in the entire cohort of 5062 patients is 18.7%.

As shown in Table 2, multivariate logistic regression analysis revealed that age between 51 and 61, male sex, higher BMI greater than 38 kg/m^2, and the presence of CHF, CRF, HTN, Asthma/COPD were independently associated with SDB (all p-values<0.005). However, race, atrial fibrillation and type 2 diabetes were not significantly associated with SDB. The likelihood ratio (LR) of SDB with ODI of $\geq$ 15 was 6.47 and ODI of > 20 was 9.19 (Table 4). The demographic characteristics of patients who had HRPO while in the hospital but did not follow-up at our sleep center for a PSG were compared with patients who had HRPO and subsequent PSG. Those who had both procedures were more likely to be Black and had a statistically higher

percentage of many, but not all comorbid medical conditions. However, the differences were relatively small. (Table 5).

As shown in Figure 2, there was a strong correlation between inpatient ODI and outpatient AHI with an AUC of 0.83 on the receiver operator curve using AHI $\geq$ 5 for confirmation of SDB. The relative Bland-Altman plot (Figure 3, Table 3) revealed that there was no significant bias when using ODI versus AHI to define SDB.

Survival curves for the 149 patients with SDB and adherent with PAP therapy and the 309 patients with SDB who were non-adherent were compared (Figure 4). The mean and median follow-up durations were 609 and 570 days respectively. In contrast to non-adherent patients, those who were adherent to PAP therapy were found to have significantly better survival (Log-rank test p=0.016). In an inverse probability weighted survival analysis (using propensity score), these differences were confirmed and were even more statistically significant (p-value=0.001).

Discussion

In this analysis of a large database of hospitalized patients, we confirmed that there is a high prevalence of undiagnosed SDB. Furthermore, follow-up of these patients for a mean of 609 days demonstrated that those who were adherent to PAP had a survival advantage in comparison to those who were non-compliant. These findings add to the

larger body of evidence that diagnosis and treatment of SDB with PAP can reduce long-term mortality.

In our single center database of more than 5000 patients, the estimated prevalence of undiagnosed SDB was 18.7%. The true prevalence rate may be even higher if there are patients who screened falsely negative. In contrast, recent estimates of the prevalence of SDB in the community are much higher[1,19,20] with 83.8% of men found to have an AHI $\geq$ 5 in one study[21]. It is likely that differences between our results and these general population estimates are related to dissimilarities in population characteristics, methods of ascertainment and definitions of SDB. Irrespective of the true prevalence rate in hospitalized patients, it appears that there are large numbers of unrecognized SDB patients in this population.

Prior data suggests that SDB in hospitalized patients is associated with greater morbidity and mortality. This suggests that SDB treatment is an area that may have potential for improving outcomes. A large multi-center study of SDB in hospitalized type 2 diabetes patients showed that over 60% of the patients had an AHI $\geq$5 and a quarter of the patients had moderate to severe OSA[22]. Shear et al screened hospitalized elderly patients and identified 40% as high-risk for OSA. These high-risk patients were also found to have reduced sleep (as measured by actigraphy) and poor self-reported sleep quality during their hospital stay[23]. A recent study found OSA to be a risk factor for post-operative respiratory failure requiring ICU transfer in patients undergoing orthopedic surgery[24]. In a large prospective study of patients hospitalized for acute heart failure,

diagnosis of SDB was independently associated with post-discharge mortality[25]. Lindenauer et al showed that among patients hospitalized with pneumonia presence of OSA increases risk for intubation, ICU transfers and higher cost of care[26].

A few recent studies have shown that early intervention with PAP therapy in patients detected to have SDB in hospitalized settings may improve clinical outcomes. Kauta et al showed that early detection and treatment of OSA in patients admitted to cardiac care unit (CCU) reduced 30-day readmission[10]. Likewise, we studied patients admitted with acute heart failure who were diagnosed with SDB in the hospital. Early intervention with PAP therapy resulted in a significant reduction in 6-month readmission in those compliant with therapy[11]. A similar reduction in readmission after early PAP intervention was also shown by our group in patients admitted with a COPD exacerbation and diagnosed with SDB. Early recognition of high-risk patients for OSA in hospitalized patients also predicted more frequent rapid response events which were reduced in patients who were successfully intervened with PAP therapy[27].

The major finding in this study was that patients treated and compliant on PAP therapy showed a significant survival advantage compared to those who were non-compliant. We do not believe that differences in various comorbidities explains the observed survival advantage of PAP adherent patients in that there were few differences in the prevalence of important comorbid conditions between the two groups and this observation was supported using an inverse propensity score analysis which accounted for differences between the two groups. This finding also is consistent with our recent

data targeting CHF patients. In that latter analysis, we observed a trend towards improved survival in patients compliant with PAP therapy; however, it did not reach statistical significance due to the small numbers of patients. In this large sample size comprising patients with various co-morbid conditions, we extend our previous findings by demonstrating a significant survival benefit in patients with SDB who were compliant with PAP therapy compared to non-compliant patients. In addition, our current analysis includes not only CHF patients, but patients with other medical conditions. Thus, our findings have greater generalizability to a broader spectrum of hospital populations. Our data suggest that once SDB is identified in hospitalized patients, concerted efforts need to be made to initiate and maintain effective PAP therapy.

This study also supports our prior contention that HRPO derived ODI in hospitalized patients provides similar results in comparison to a PSG derived AHI. This two-tier system of screening with a clinical questionnaire and an objective HRPO in those who are positive can yield a high positive predictive value as noted by 87% of the PSG's resulting in a positive diagnosis of SDB. Patients who underwent HRPO in the hospital but failed to get a subsequent PSG at our center were less likely to have several serious comorbid medical conditions. However, the differences between those who did not have a confirmatory PSG and those who did not were small and unlikely to be clinically significant.

Although our study has several important findings, it should be interpreted with the following limitations. First, it is a retrospective observational study. Patients were not

prospectively randomized to PAP therapy or sham PAP therapy. It is possible that despite similarities in comorbid conditions between the two groups, factors other than PAP adherence explained the differences in survival that were observed. However, we applied propensity score analysis to account for systematic differences in baseline characteristics between treated and untreated subjects when estimating the effect of treatment on outcomes and the model continued to show a significant statistical difference. Second, the screening was limited to weekdays. However, we do not believe that the patient demographics were different during weekend admissions. Third, due to logistical limitations the screening was limited to medical services only and does not apply to other services. Third, except for CHF patients, patients were screened only if their BMI was $\geq$ 30 kg/m^2. Thus, our findings cannot be extrapolated to non-obese patients. Fourth, only 680 (21%) of all screen positive patients underwent a PSG study post discharge at our facility. However, the high correlation of ODI on the HRPO with the PSG AHI suggests that in this population, the ODI is a reasonable surrogate to identify SDB. Finally, patients who screened negative did not undergo either HRPO or PSG. Thus, some patients may have been incorrectly designated as not having SDB.

Despite the afore-mentioned limitations, our study has several strengths. To our knowledge, this is the largest database of SDB in hospitalized patients to date. As such, it provides insight into the extent of undiagnosed and untreated SDB in hospitalized patients and their outcomes. It also demonstrates the utility of using existing clinical

personnel with minimal additional training (e.g., respiratory therapists) to administer a simple screening SDB questionnaire in a hospital population.

In conclusion, this analysis of a large database of over 5000 patients confirmed our prior findings of high burden of unrecognized SDB in obese hospitalized patients in selected medical services. Furthermore, it showed that early intervention and adherence to therapy imparted a survival benefit. We recommend routine screening and intervention of obese patients admitted to hospital medical services.

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Table 1. Demographic and baseline characteristics (n=5062)

Parameter	*Compliant Patients (N=149)*	*Non-Compliant Patients (N=309)*	*All Patients (N=5062)*
Gender - n(%)			
Male	74 (50.0%)	177 (57.5%)	2477 (49.0%)
Female	74 (50.0%)	131 (42.5%)	2577 (51.0%)
Age (yr)[a]			
n	149	309	5062
Mean (SD)	63.8 (10.8)	59.2 (13.0)	60.7 (15.2)
Median	65	59	61
Min, Max	30.0, 86.0	19.0, 92.0	17.0, 102.0
Race - n(%)[a]			
White	97 (65.5%)	120 (39.0%)	2674 (53.0%)
Black	44 (29.7%)	162 (52.6%)	2022 (40.1%)
Other	7 (4.7%)	26 (8.4%)	346 (6.9%)
BMI (kg/m^2)			
n	149	309	5056
Mean (SD)	37.4 (9.9)	37.1 (9.3)	34.8 (8.3)
Median	35	36	33
Min, Max	18.0, 73.2	16.1, 70.7	14.0, 99.9
Neck Circumference (cm)			
n	25	47	586
Mean (SD)	16.7 (1.9)	16.4 (2.0)	16.0 (2.1)
Median	17	17	16
Min, Max	13.5, 19.5	12.5, 21.0	11.5, 25.5
AHI (events/hour)			
n	149	309	680
Mean (SD)	33.4 (29.5)	34.2 (30.1)	30.0 (30.3)
Median	22	22	18
Min, Max	5.0, 121.0	5.0, 145.0	0.0, 145.0
ODI (events/hour)			
n	94	200	1410
Mean (SD)	29.3 (24.7)	27.5 (23.6)	21.4 (21.4)
Median	21	22	14

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Parameter	*Compliant Patients (N=149)*	*Non-Compliant Patients (N=309)*	*All Patients (N=5062)*
Min, Max	0.0, 113.0	0.0, 124.0	0.0, 127.0
PASP (mmHg)			
n	28	80	1165
Mean (SD)	48.5 (16.3)	44.9 (15.6)	42.4 (15.6)
Median	45	45	40
Min, Max	20.0, 105.0	15.0, 85.0	8.0, 105.0
EF			
n	67	162	1968
Mean (SD)	56.4 (17.6)	53.0 (18.7)	53.4 (18.1)
Median	60	60	60
Min, Max	20.0, 80.0	10.0, 80.0	5.0, 88.0
Time Oxygen <88% (minutes)			
n	67	158	1300
Mean (SD)	32.6 (61.7)	20.1 (39.2)	17.2 (43.5)
Median	4	3	1
Min, Max	0.0, 261.0	0.0, 284.0	0.0, 417.0
Comorbidities			
Heart Failure	26 (17.4%)	75 (24.3%)	882 (17.4%)
Asthma/COPD [b]	27 (18.1%)	87 (28.2%)	971 (19.2%)
Coronary Artery Disease	63 (42.3%)	120 (38.8%)	1798 (35.5%)
Diabetes	64 (43.0%)	141 (45.6%)	1849 (36.5%)
Hypertension	115 (77.2%)	232 (75.1%)	3181 (62.9%)
Chronic Renal Failure	33 (22.1%)	94 (30.4%)	866 (17.1%)
A-Fib	32 (21.8%)	43 (14.0%)	905 (17.9%)
Concomitant Medications			
ACE, ARB, Isosorbide, Hydralazine	79 (53.0%)	148 (47.9%)	1802 (35.6%)
Beta Blockers	79 (53.0%)	158 (51.1%)	2328 (46.0%)
Calcium Channel Blocker	35 (23.5%)	99 (32.0%)	1246 (24.6%)
Diuretics	94 (63.1%)	168 (54.4%)	2089 (41.3%)

[a] $p<0.0001$ Compliant vs. Non-Compliant Patients

[b] $p=0.03$ Compliant vs. Non-Compliant Patients

Table 2. Predictors of SDB (AHI ≥5). Logistic regression analysis (all demographic variables).

Predictor	Odds Ratio	95% Wald Confidence Limits		p-value
Age 51-61 vs <51	1.4	1.1	1.8	0.005
Age 61-72 vs <51	1.2	0.9	1.5	
Age >72 vs <51	0.9	0.6	1.2	
Sex (Females v. Males)	0.7	0.6	0.9	0.001
Race (Black v. White)	1.2	1.0	1.5	0.11
Race (Other v. White)	1.0	0.7	1.4	
BMI 30.6-33.4 vs <30.6	0.8	0.6	1.1	<0.0001
BMI 33.4-38.3 vs <30.6	1.1	0.8	1.4	
BMI >38.3 vs <30.6	1.9	1.5	2.4	
Heart Failure	1.4	1.1	1.8	0.004
Asthma/COPD	1.6	1.3	2.0	<0.0001
Coronary Artery Disease	1.0	0.8	1.2	0.98
Diabetes	1.0	0.9	1.3	0.64
Hypertension	1.8	1.5	2.2	<0.0001
Chronic Renal Failure	1.6	1.3	2.0	<0.0001
A-Fib	1.0	0.7	1.2	0.72

Table 3: Sensitivity, specificity and positive likelihood ratio and 95% confidence intervals for various ODI thresholds (SDB defined as PSG AHI ≥ 5).

ODI Threshold	sensitivity	specificity	LR+	LR-
≥5	0.89 (0.85, 0.92)	0.48 (0.34, 0.63)	1.71 (1.3, 2.2)	0.23 (0.15, 0.35)
≥10	0.74 (0.69, 0.79)	0.78 (0.64, 0.88)	3.37 (2.0, 5.7)	0.33 (0.26, 0.42)
≥15	0.65 (0.60, 0.70)	0.90 (0.78, 0.97)	6.47 (2.8, 14.9)	0.39 (0.33, 0.46)
≥20	0.55 (0.50, 0.60)	0.94 (0.83, 0.99)	9.19 (3.1, 27.6)	0.48 (0.42, 0.54)

Table 4. Comparison of baseline characteristics of patients undergoing high resolution pulse oximetry (HRPO) or HRPO and polysomnography (PSG). P-values are from two-sample t-tests or Fisher's exact tests, as appropriate.

Characteristic	*HRPO only (N=992)*	*Both PSG & HRPO (N=418)*	*P-value*
Age (y), Mean ± SD	61 ± 15	60 ± 13	0.11
Median (IQR)	61 (20)	59 (16)	
BMI, Mean ± SD	35 ± 10	37 ± 10	0.002
Median (IQR)	34 (10)	35 (11)	
ODI, Mean ± SD	19 ± 20	26 ± 24	< 0.0001
Median (IQR)	12 (23)	20 (30)	
AHI, Mean ± SD	-	30 ± 30	-
Median (IQR)	-	18 (37)	
Male, n (%)	539 (54%)	220 (53%)	0.56
Black, n (%)	382 (39%)	192 (46%)	0.01
Coronary Artery Disease, n (%)	390 (39%)	171 (41%)	0.59
Heart Failure, n (%)	256 (26%)	115 (28%)	0.51
Chronic Renal Failure, n (%)	183 (18%)	104 (25%)	0.01
Asthma/COPD, n (%)	209 (21%)	108 (26%)	0.06
Diabetes, n (%)	408 (41%)	182 (44%)	0.44
Hypertension, n (%)	687 (69%)	311 (74%)	0.06
A-Fib, n (%)	236 (24%)	70 (17%)	0.004
Diuretics, n (%)	480 (48%)	233 (56%)	0.01
ACE, ARB, Isosorbide, Hydralazine, n (%)	390 (39%)	209 (50%)	0.0003
Beta Blocker, n (%)	500 (50%)	210 (50%)	0.95
Calcium Channel Blocker, n (%)	254 (26%)	125 (30%)	0.10

Table 5. Predictors of SDB (AHI ≥5). Logistic regression analysis (final model using stepwise logistic regression).

Predictor	Odds Ratio	95% Wald Confidence Limits		p-value
Age 51-61 vs <51	1.4	1.1	1.8	0.001
Age 61-72 vs <51	1.1	0.9	1.4	
Age >72 vs <51	0.8	0.6	1.1	
Sex (Females v. Males)	0.7	0.6	0.9	0.002
BMI 30.6-33.4 vs <30.6	0.8	0.6	1.0	<0.0001
BMI 33.4-38.3 vs <30.6	1.1	0.8	1.4	
BMI >38.3 vs <30.6	1.9	1.5	2.5	
Heart Failure	1.4	1.1	1.7	0.004
Chronic Renal Failure	1.7	1.4	2.1	<0.0001
Hypertension	1.9	1.5	2.3	<0.0001
Asthma/COPD	1.7	1.3	2.0	<0.0001

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Figure 1. Flow chart showing patient recruitment during hospitalization.

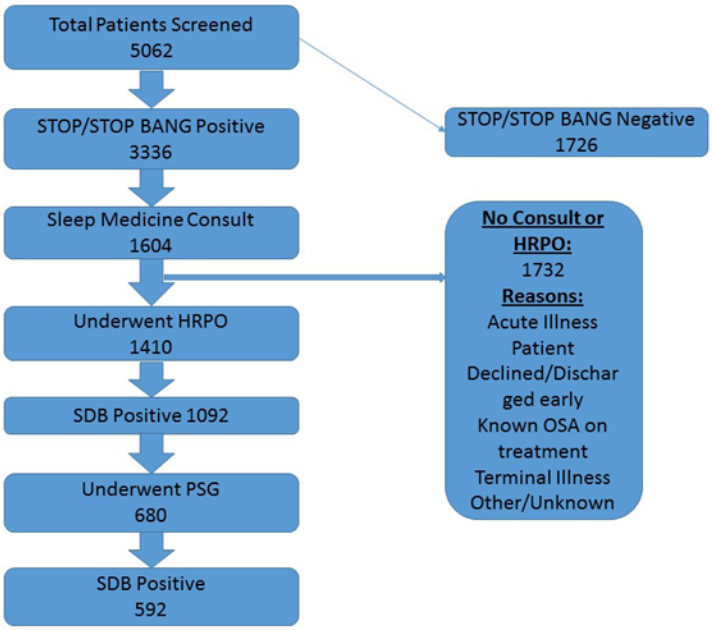
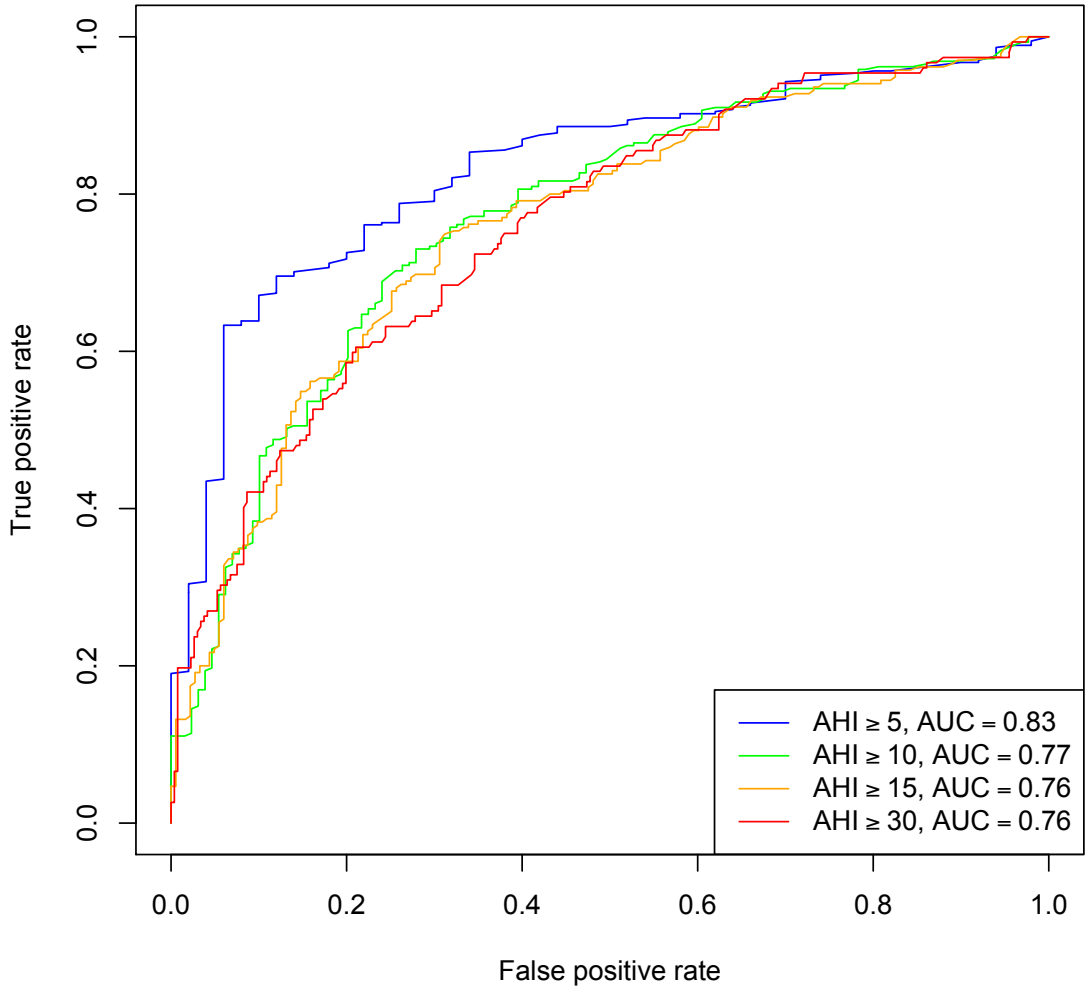


Figure 2: Receiver-Operator curve for predicting PSG sleep apnea (with four different AHI thresholds) using ODI.



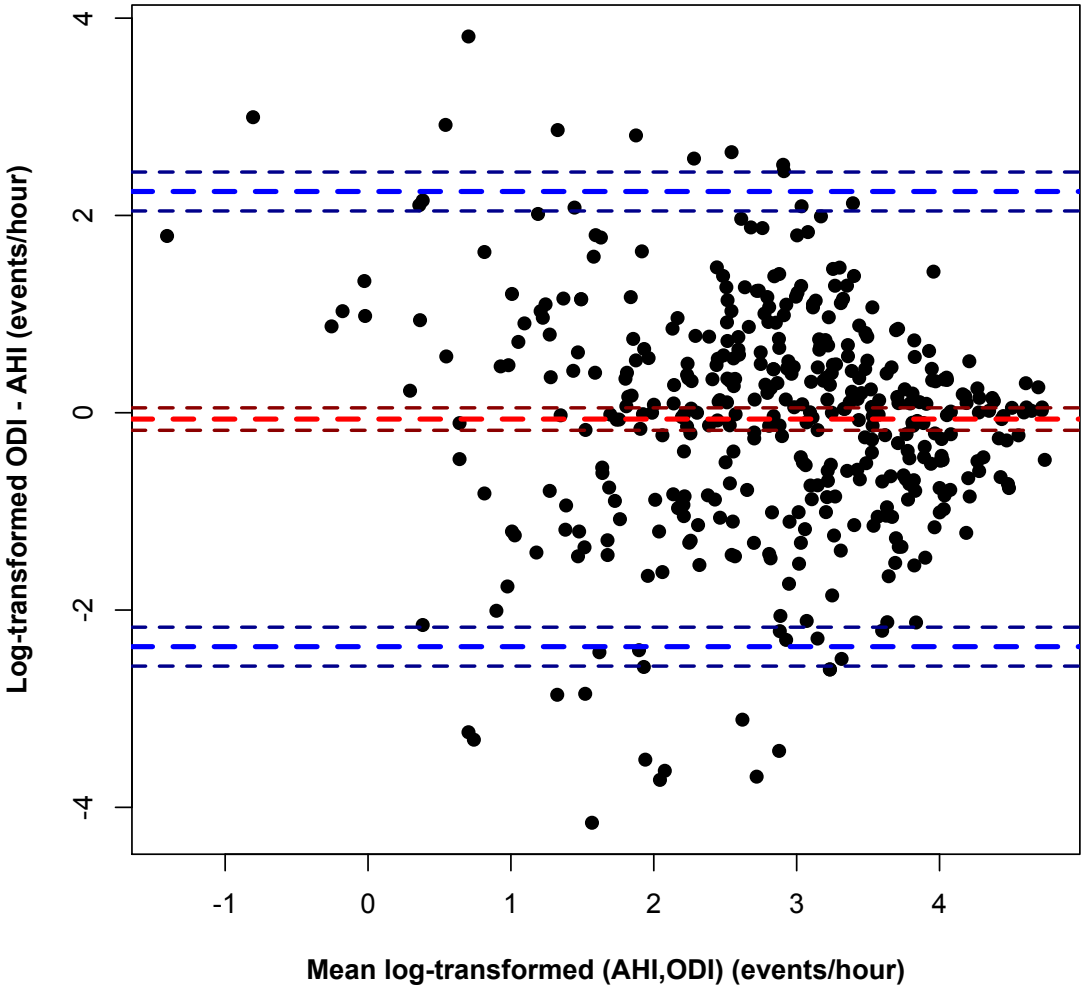


Figure 3: Bland-Altman plot of log-transformed AHI and ODI measurements. Thick blue dashed lines represent the 95% upper and lower limits of agreement; thinner dark blue dashed lines represent the 95% confidence intervals for the upper and lower limits of agreement. Thick red dashed line represents the mean bias; thinner dark red dashed lines represent the 95% confidence intervals for the mean bias.

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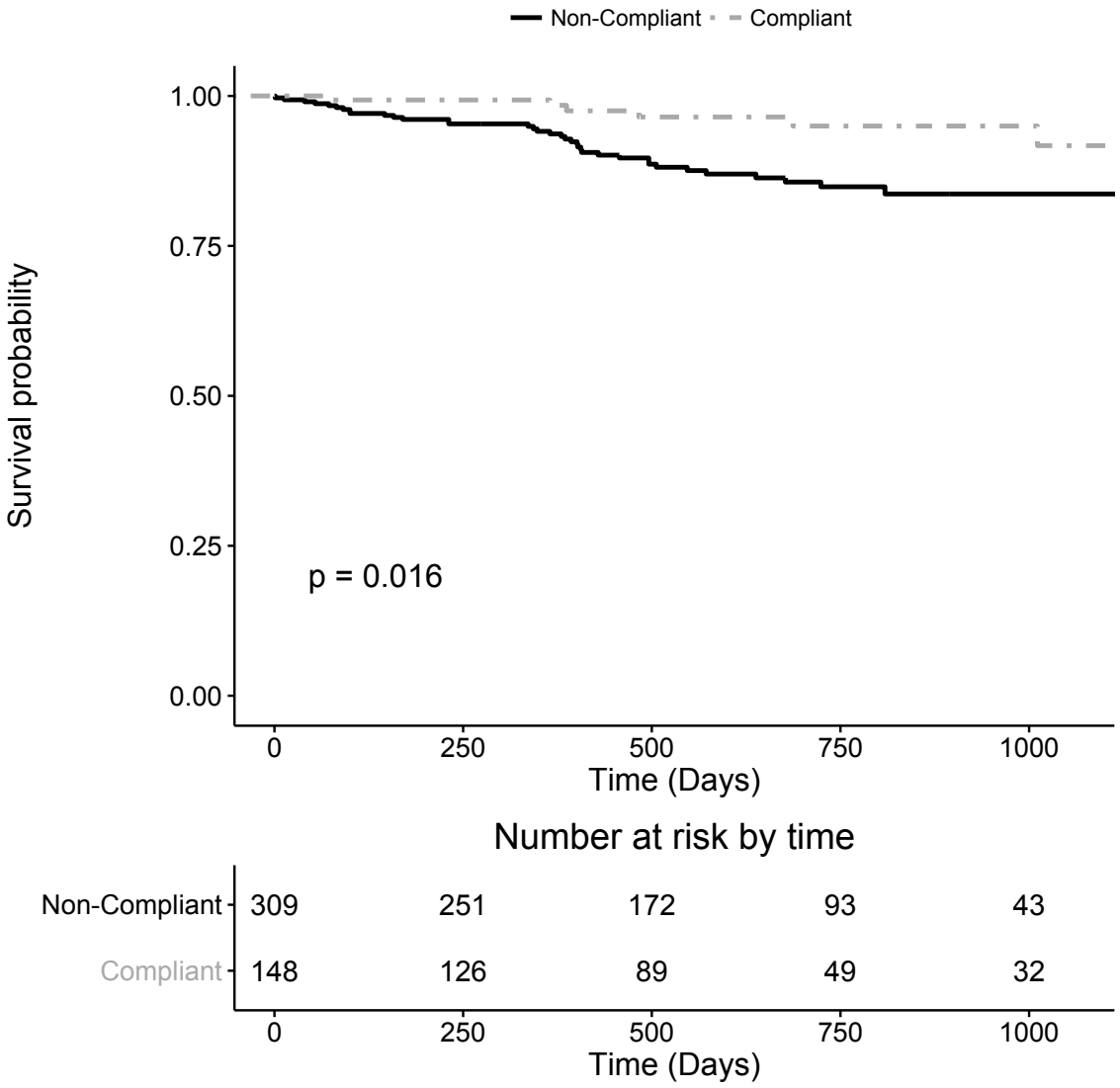
Figure 4. Kaplan Meir survival curves for patients complaint with PAP therapy versus non-compliant.



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