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PREDICTORS OF INTRAPROCEDURAL RESPIRATORY BRONCHOSCOPY COMPLICATIONS

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Abstract

Purpose: Sleep apnea can increase adverse outcomes during ambulatory surgery but not during gastrointestinal endoscopy. We hypothesize that STOP-BANG is associated with intraprocedural bronchoscopy respiratory complications.

Methods: Consecutive patients undergoing bronchoscopy under moderate sedation were prospectively administered the STOP-BANG questionnaire. Participants were assessed for intraprocedural complications including hypoxemia ($SpO_2 \leq 85\%$), bradypnea (rate<8), premature procedure cessation as well as use of nonrebreather mask, bag mask ventilation, jaw lift/chin tilt, nasal/oral airway, and naloxone administration. Associations were assessed via logistic regression. Lasso was used for multivariable model variable selection.

Results: The 223 participants – mean age 61.1±15.5 years, BMI 25.4 (IQR: 22.4–30.7), 50.7% female, and 45.3% inpatient – had a high rate of respiratory complications (37.7%). There were no associations between STOP-BANG score and respiratory complications (OR=1.07, 95% CI: 0.92–1.25). Asthma was protective in univariable models (OR=0.26, 95%CI: 0.04–0.98) while endobronchial ultrasound (OR=2.34, 95% CI: 1.35–4.10) and number of procedure types (OR=1.24, 95% CI: 1.01–1.51) was associated with increased complications. The following factors were associated with respiratory complications in both multivariable and univariate analyses: increasing age (OR=1.28 per decade, 95% CI: 1.03–1.61), baseline oxygen use per each liter per minute (OR=1.57, 95% CI: 1.21–2.09), and bronchoscopy duration (OR=1.20 per 10 minutes, 95% CI: 1.08–1.33).

Conclusions: Bronchoscopy respiratory complications are common. STOP-BANG was not associated with increased immediate bronchoscopy complication risk. Increasing age, oxygen use, and bronchoscopy duration were associated with respiratory complications; increased vigilance in these circumstances may prevent complications.

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CONFLICT OF INTERST

AMM and JK have not conflicts of interest to declare. KPS receives research support from Inspire Medica Systems, and is a consultant for Galvani Bioelectronics, Jazz Pharmaceuticals, Sommetrics, and Seven Dreamers.

Keywords

STOP-BANG; obstructive sleep apnea; procedure; complication; bronchoscopy

INTRODUCTION

Obstructive sleep apnea (OSA) is common: 10% of adults have moderate to severe sleep disordered breathing.[1] However, over 85% of OSA cases are undiagnosed.[2] OSA is characterized by repetitive complete or partial airflow cessation (apneas and hypopneas, respectively) secondary to upper airway instability. Sedatives and opioids used in moderate sedation cause a dose-dependent decrease in upper airway muscle tone exacerbating the underlying OSA physiology of airway instability.[3-5]

OSA has been recognized as a significant contributor to perioperative morbidity and is associated with increased rates of respiratory events, atrial fibrillation, cardiac ischemia, heart failure, and unplanned intensive care unit transfer.[6-8] The risks are increased in both major and ambulatory surgery.[9,10] Because of this increase in risk, current guidelines advocate pre-operative OSA screening for all patients.[8] In addition, peri-operative use of positive airway pressure for treatment and consideration for increased monitoring post-procedure is recommended.[8,9]

Studies examining STOP-BANG screening in gastrointestinal endoscopy have not found an association with procedural complications.[11-16] Flexible bronchoscopy and gastrointestinal endoscopy share many features: outpatient same-day procedures performed under moderate sedation with no anesthesiologist present. However, unlike gastrointestinal endoscopy, bronchoscopy decreases the tracheal lumen by taking up airway space with the bronchoscope and is generally of longer duration. Therefore, bronchoscopy may have heightened risk of airflow limitation in an already compromised airway in OSA that is additionally prone to collapse secondary to sedative medications for procedural sedation. Data on bronchoscopy complications are sparse. We hypothesize that STOP-BANG will increase odds of intraprocedural complications, primarily focusing on airway compromise and respiratory depression, in bronchoscopy with moderate sedation.

MATERIALS AND METHODS

This was a prospective, observational, single-center study of adult patients undergoing bronchoscopy with moderate sedation at a tertiary referral academic medical center. Moderate sedation was administered by the physician performing the bronchoscopy and defined as a level of sedation where the patient has preserved spontaneous ventilation without need for additional airway support and responds purposefully to verbal or tactile stimuli. Fellows under the supervision of an attending physician perform most bronchoscopies. As part of standard care, bronchoscopy nurses administered the STOP-BANG questionnaire to all patients undergoing bronchoscopy in the bronchoscopy suite. Patients with a tracheostomy or tracheal stoma were excluded from analysis. There were 238 cases performed under moderate sedation assessed July 2015 – June 2016. Two individuals did not complete the questionnaire and 13 had incomplete data, leaving 223 participants with

complete STOP-BANG data for the final analytic cohort. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The University Hospitals Cleveland Medical Center IRB reviewed this project and deemed it exempt from IRB review.

STOP-BANG Screening

Consisting of 8 dichotomous question, the STOP-BANG screening instrument has been validated in both the general population and peri-operatively for OSA screening.[8,17,18] A STOP-BANG score of 3 or more has a high sensitivity for moderate-severe obstructive sleep apnea defined by an apnea hypopnea index ≥ 15 in the general population (89%) and surgical patients (93%).[19,20] The STOP-BANG screening questionnaire, which consists of 8 yes/no questions, was administered to all patients undergoing bronchoscopy with moderate sedation in the bronchoscopy suite before the procedure (Table 1). Bronchoscopy nurses measured neck circumference before the bronchoscopy. Bronchoscopists were not blinded to STOP-BANG score.

Other Measures

Patient demographics were obtained from the bronchoscopy documentation. Body mass index (BMI, kg/m^2) was calculated from height and weight documented on day of procedure. Pre-bronchoscopy interview and chart review identified history of the following: cardiovascular disorders (coronary artery disease, coronary stent, coronary artery bypass graft, heart failure, and atrial fibrillation or flutter), pulmonary diseases (chronic obstructive pulmonary disease, asthma, sarcoidosis, interstitial lung disease, and pulmonary hypertension), neuromuscular diseases, and chronic kidney disease. We defined opioid or benzodiazepine use as concurrent prescription of medications at the time of bronchoscopy. Baseline oxygen use at the start of bronchoscopy, either home oxygen prescription if outpatient or in-hospital oxygen supplementation, was recorded in liters per minute; the bronchoscopy suite protocol is to administer a minimum of 2 liters per minute via nasal canula to anyone undergoing bronchoscopy. Bronchoscopy length was calculated from recorded start and end times for the procedure. Bronchoscopy procedure types – airway exam, bronchoalveolar lavage, biopsy, cytology brushing, microbiologic brushing, linear probe endobronchial ultrasound (EBUS), interventional procedures (fiducial marker placement, stent placement or manipulation, and bronchial balloon dilation), as well as bronchoscopy at the same time as gastrointestinal endoscopy were abstracted from procedural documentation. All procedures were done under moderate sedation, which was the standard for bronchoscopy EBUS at the time. Total number of different procedure types was calculated.

Respiratory complications were identified from bronchoscopy documentation and a separate moderate sedation adverse event report. Transient hypoxemia is not uncommon during bronchoscopy; because of this, the evaluated bronchoscopy suite protocol instituted interventions at a higher threshold of desaturation ($SpO_2 \leq 85\%$), which initiates a nurse-led protocol focusing on modulation of oxygen administration to improve oxygenation. Attending pulmonologists determined need for and timing of naloxone administration and

rescue interventions such as jaw lift, chin tilt, and nasal or oral airway use. The primary outcome was a composite of respiratory complications during the bronchoscopy procedure: hypoxemia ($SpO_2 \leq 85\%$ at any time during procedure), bradypnea (respiratory rate ≤ 8), naloxone administration, jaw lift or chin tilt, nasal or oral airway use, nonrebreather mask use, bag mask ventilation, or premature end to the procedure. To account for differing operator thresholds for intervention, analyses of the composite of hypoxemia and bradypnea were also evaluated since these complications are not dependent on operator response.

Statistical Analysis

Participant characteristics were summarized as mean ± standard deviation (SD), median (interquartile range, IQR), or n (%) and compared across categories of STOP-BANG score using Chi-squared test for categorical variables, t-test for normally distributed continuous variables, and Kruskall-Wallis test for continuous variables with skewed distributions.

Binary logistic regression was used to conduct univariate and multivariate analyses. Primary analyses were on the composite respiratory complication outcome. Secondary analyses evaluated individual respiratory complications and a composite of hypoxemia and bradypnea and severe respiratory complications (bag mask ventilation, intubation, naloxone use, and early procedure discontinuation). Since all variables were collected based on biological plausibility in affecting immediate respiratory complications, multivariate analyses were conducted on variables selected using the least absolute shrinkage and selection operator (LASSO) technique, a model selection method. Cross validation was used to select the best shrinkage parameter.

STOP-BANG was evaluated in several ways. STOP-BANG was evaluated as a continuous variable (0–8 scale) for the primary and secondary analysis. To test the robustness of the analysis, univariate sensitivity analyses were conducted using the standard STOP-BANG cutoff (≥3 vs. <3) and alternative STOP-BANG cutoffs which may increase instrument specificity – (1) STOP-BANG ≥ 5 [17] and (2) STOP-BANG ≥3 with serum bicarbonate ≥ 28 [21] – in relation to composite respiratory complications.

Stratified analyses based on inpatient vs. outpatient status prior to bronchoscopy were conducted because the two populations have different bronchoscopy indications and illness severity. Subset analyses on EBUS procedures were conducted because of potential substantive differences in respiratory complications secondary to longer duration and larger bronchoscope diameter compared to the standard bronchoscopy. Spearman rank correlation (ρ) was used to assess for strength of correlation.

Results are presented as odds ratios (OR) with 95% confidence intervals (CI). All significance levels reported are two-sided and all analyses were conducted using R version 3.4.2 (R Core Team, Vienna, Austria).[22]

RESULTS

Study Population

The study cohort (n=223) were 50.7% female and had a mean age of 61.1±15.5 years with median body mass index of 26.9±7.1 kg/m^2 (Table 2). Nearly half of the cohort was hospitalized at the time of bronchoscopy and likely had more risk than ambulatory bronchoscopy patients because of both their acute condition and comorbidities. These patients had an overall high disease burden with 30.5% having some form of cardiovascular disease and 41.7% having a chronic pulmonary disease diagnosed prior to procedure. Participants had an average of 2.4 ± 1.4 different procedure types during bronchoscopy with a median duration of 30. minutes (IQR: 15–58 minutes). EBUS was highly correlated with procedure duration ($\rho = 0.80$). There were 84 (37.7%) individuals with respiratory complications of which the majority were for nonrebreather mask use (n= 67) and hypoxemia (n=58) – two highly correlated complications ($\rho = 0.77$). Bradypnea (n=10), jaw thrust/chin lift (n=25), nasal/oral airway (n=5), bag mask ventilation (n=4), intubation (n=1), naloxone use (n=3), and premature bronchoscopy end (n=6) were much less common.

Primary analyses

There was no association between STOP-BANG screening and a composite of immediate respiratory complications (Table 3). Age, history of asthma, baseline oxygen use, EBUS, number of procedure types performed, and bronchoscopy duration were significantly associated with immediate respiratory bronchoscopy complications in univariate analyses. History of asthma was associated with a protective effect (OR = 0.26, 95% CI: 0.04 – 0.98). Patient characteristics – increasing age (OR = 1.32, 95% CI: 1.09–1.61) and increased oxygen use (OR = 1.39, 95% CI: 1.09 – 1.83) – were associated with respiratory complications. EBUS (OR = 2.34, 95% I: 1.35 – 4.10) had higher magnitude of association than number of procedures types (OR = 1.24, 95% CI: 1.01 – 1.51) or procedure duration (OR = 1.21, 95% CI: 1.10 – 1.34).

The lasso-selected features included in multivariable analysis were age, baseline oxygen supplementation, and procedure duration (Table 4). An increase in age by a decade increases odds of respiratory complications (OR 1.28, 95% CI: 1.03 – 1.61). There was a mild strengthening of association between baseline oxygen need and respiratory complications (OR = 1.57, 95% CI: 1.21 – 2.09). Each ten-minute increase in bronchoscopy duration increases respiratory complication odds (OR = 1.20, 95% CI: 1.08–1.33). The R^2 of this multivariable model was 19%.

Secondary analyses

There were no significant associations between STOP-BANG and individual respiratory complications, the composite outcome of hypoxemia and bradypnea, or severe respiratory complications (Table 5). Only age (OR = 1.82 per decade, 95% CI: 1.07 – 3.51) was a significant predictor of severe respiratory complications in multivariate models including age, baseline oxygen use, and procedure duration.

Individuals undergoing EBUS were older (65.7 vs. 57.4 years) with less asthma and renal disease. Bronchoscopies with respiratory complications were characterized by significantly fewer bronchoalveolar lavages and more interventional procedures (6.9% vs. 0.8%), multiple procedure types (3.2 vs. 1.8), and longer bronchoscopy duration (65.5 vs. 19.2 minutes) with concomitant higher procedural dose of fentanyl (172 vs. 51 mcg) and midazolam (8.2 vs. 4.4 mg). However, there was no significant association between STOP-BANG score and respiratory complications in analyses stratified by EBUS status (OR = 1.27, 95% CI: 0.99–1.65 in EBUS and OR = 0.95, 95% CI: 0.77 – 1.16 in procedures without EBUS).

Outpatients undergoing bronchoscopy were older (63.7 vs. 58.0 years) with higher baseline serum bicarbonate (27.8 vs. 26.5) and were more likely to undergo multiple procedure types (2.8 vs. 2.0) including EBUS (59% vs. 29%) and biopsies (50% vs. 30%). Longer bronchoscopy duration (49.5 vs. 28.9 min) with attendant increase in sedation dose was found in outpatients. There were no significant associations between STOP-BANG and respiratory complications stratified on inpatient status (OR = 1.15, 95% CI: 0.93–1.43 in inpatients and OR = 1.00, 95% CI: 0.81–1.24 in outpatients).

DISCUSSION

In this prospective single-center study, STOP-BANG score was not associated with bronchoscopy complications even when examined by a variety of criteria to define “high risk”. An increase in respiratory complications was associated with increasing need for oxygen supplementation, age, and bronchoscopy duration in multivariable models, which accounted for 19% of the variation in immediate respiratory complications during bronchoscopy under moderate sedation.

Contrary to reports from outpatient surgery, previous work in gastrointestinal endoscopy procedures has not found relationships between patients with OSA or at high risk for OSA and subsequent complications.[12,14-16,23,24] A meta-analysis of gastrointestinal endoscopy found no associations between OSA and complications even in groups stratified by type of anesthesia.[6] There are several explanations for this difference. First, procedure time is likely to be significantly shorter for endoscopy and bronchoscopy performed under moderate sedation than for those procedures requiring general anesthesia (both endoscopic and outpatient surgery). Second, moderate sedation does not lead to a prolonged recovery time compared to general anesthesia. Third, unlike in outpatient surgery, a new prescription for opioids is highly unusual after endoscopy or bronchoscopy. However, potential associations between OSA and procedural complications remain an open question considering the substantial increase in monitored anesthesia care with general anesthesia for bronchoscopy sedation.

The multivariate model selected via lasso did not select asthma, use of EBUS, or number of procedure types as complication risks. This is likely secondary to correlation between these factors and the ones included (i.e., EBUS is correlated with increased bronchoscopy duration and number of procedure types while asthma is correlated with lower age). Since patients with asthma have increased risk of bronchospasm with bronchoscopy, additional measures

(premedication and increased caution) may have been implemented leading to an overall decreased odds of adverse respiratory events.

There are several strengths to this study. This is the largest study of the association between STOP-BANG screening and procedural respiratory complications during bronchoscopy. We employed systematic data collection on all individuals undergoing bronchoscopy under moderate sedation at a tertiary medical center. In addition, we evaluated several definitions of STOP-BANG cutoffs for high OSA risk. Since the STOP-BANG questionnaire is a commonly-used and guideline-recommended instrument for assessing OSA risk peri-operatively, the use of this instrument allows for comparison to studies in other surgical and procedural situations.[8] This analysis did not find associations between STOP-BANG and immediate respiratory complications during bronchoscopy. However, this study cannot inform whether OSA is a risk factor for delayed complications after the procedure.

There were several limitations to this study. This is a single center study. We did not specifically account for practice differences between individual providers that are influenced by institutional, regional, and provider-specific patterns of care, which may account for a significant portion of the variation in bronchoscopy complications. Other potential confounders, which may be significantly associated with respiratory complications such as measures of lung function and severity of disease, were also unavailable. The STOP-BANG screening is a proxy for the variable of interest, OSA. Only intraprocedural complications, primarily focused on respiratory depression and airway compromise, were examined, thereby limiting applicability to those complications that occur hours or days after procedure completion. Etiology and acuity of hypoxemia requiring oxygen supplementation above the local standard of care (2 lpm) during bronchoscopy was not available for analysis. Additionally, capnography is not routinely used in our medical center for this procedure; therefore, distinction of hypoxemia with and without hypercapnia was not possible. Finally, the cohort was not powered to assess for an increase in level of care or other clinically significant but rare complications related to bronchoscopy.

The next logical step would be to evaluate a large payer database of all individuals undergoing bronchoscopy with moderate sedation and assess whether diagnosed sleep apnea are associated with clinically significant complications post-procedure (e.g. increase in level of care, emergency department visit, or hospitalization). Additional future directions should evaluate for peri-procedural complications for bronchoscopy conducted under general anesthesia.

Overall, we found no association between STOP-BANG score and intraprocedural respiratory complications during bronchoscopy under moderate sedation. Increasing procedure duration, need for oxygen supplementation, and age were associated with immediate respiratory complications. OSA diagnosis should be part of the pre-procedure history, and anyone at high risk for OSA should be evaluated. However, using an OSA screening tool before bronchoscopy had little added value in predicting intra-procedural respiratory depression or airway compromise. The results of this study provide some reassurance that performing bronchoscopy before establishing OSA diagnosis and treatment may not be associated with increased procedural complications.

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ABBREVIATIONS

BMI	Body mass index
CI	Confidence interval
EBUS	Endobronchial ultrasound
IQR	Interquartile range
LASSO	least absolute shrinkage and selection operator
OR	Odds ratio
OSA	Obstructive sleep apnea
SD	Standard deviation
SpO_2	Oxygen saturation
STOP-BANG	Screening tool for obstructive sleep apnea

REFERENCES

1. Peppard PE, Young T, Barnet JH, Palta M, Hagen EW, Hla KM. Increased Prevalence of Sleep-Disordered Breathing in Adults. Am J Epidemiol. 2013;177(9):1006–1014. doi:10.1093/aje/kws342 [PubMed: 23589584]
2. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med. 1993;328(17):1230–1235. doi:10.1056/NEJM199304293281704 [PubMed: 8464434]
3. Drummond GB. Influence of thiopentone on upper airway muscles. Br J Anaesth. 1989;63(1):12–21. [PubMed: 2765337]
4. Drummond GB. Comparison of sedation with midazolam and ketamine: effects on airway muscle activity. Br J Anaesth. 1996;76(5):663–667. [PubMed: 8688266]
5. Hillman DR, Loadsman JA, Platt PR, Eastwood PR. Obstructive sleep apnoea and anaesthesia. Sleep Med Rev. 2004;8(6):459–471. doi:10.1016/j.smrv.2004.07.002 [PubMed: 15556378]
6. Gaddam S, Gunukula SK, Mador MJ. Post-operative outcomes in adult obstructive sleep apnea patients undergoing non-upper airway surgery: a systematic review and meta-analysis. Sleep Breath. 2014;18(3):615–633. doi:10.1007/s11325-013-0925-1 [PubMed: 24337834]
7. Kaw R, Chung F, Pasupuleti V, Mehta J, Gay PC, Hernandez AV. Meta-analysis of the association between obstructive sleep apnoea and postoperative outcome. Br J Anaesth. 2012;109(6):897–906. doi:10.1093/bja/aes308 [PubMed: 22956642]
8. American Society of Anesthesiologists Task Force on Perioperative Management of patients with obstructive sleep apnea. Practice guidelines for the perioperative management of patients with

obstructive sleep apnea: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Management of patients with obstructive sleep apnea. Anesthesiology. 2014;120(2):268–286. doi:10.1097/ALN.0000000000000053 [PubMed: 24346178]

9. Joshi GP, Ankichetty SP, Gan TJ, Chung F. Society for Ambulatory Anesthesia Consensus Statement on Preoperative Selection of Adult Patients with Obstructive Sleep Apnea Scheduled for Ambulatory Surgery: Anesth Analg. 2012;115(5):1060–1068. doi:10.1213/ANE.0b013e318269cfd7 [PubMed: 22886843]
10. Raveendran R, Chung F. Perioperative consideration of obstructive sleep apnea in ambulatory surgery. Anesthesiol Clin. 2014;32(2):321–328. doi:10.1016/j.anclin.2014.02.011 [PubMed: 24882120]
11. Andrade CM, Patel B, Gill J, et al. Safety of Gastrointestinal Endoscopy With Conscious Sedation in Patients With and Without Obstructive Sleep Apnea. J Clin Gastroenterol. 3 2015. doi:10.1097/MCG.0000000000000305
12. Cha JM. Risk of sedation for diagnostic esophagogastroduodenoscopy in obstructive sleep apnea patients. World J Gastroenterol. 2013;19(29):4745. doi:10.3748/wjg.v19.i29.4745 [PubMed: 23922472]
13. Gill J, Vidyarthi G, Kulkarni P, Anderson W, Boyd W. Safety of conscious sedation in patients with sleep apnea in a veteran population. South Med J. 2011;104(3):185–188. doi:10.1097/SMJ.0b013e318205e55e [PubMed: 21297544]
14. Khiani VS, Salah W, Maimone S, Cummings L, Chak A. Sedation during endoscopy for patients at risk of obstructive sleep apnea. Gastrointest Endosc. 2009;70(6):1116–1120. doi:10.1016/j.gie.2009.05.036 [PubMed: 19660748]
15. Mador MJ, Abo Khamis M, Nag N, Mreyoud A, Jallu S, Mehboob S. Does sleep apnea increase the risk of cardiorespiratory complications during endoscopy procedures? Sleep Breath Schlaf Atm. 2011;15(3):393–401. doi:10.1007/s11325-010-0346-3
16. Mador MJ, Nadler J, Mreyoud A, et al. Do patients at risk of sleep apnea have an increased risk of cardio-respiratory complications during endoscopy procedures? Sleep Breath Schlaf Atm. 2012;16(3):609–615. doi:10.1007/s11325-011-0546-5
17. Chung F, Subramanyam R, Liao P, Sasaki E, Shapiro C, Sun Y. High STOP-Bang score indicates a high probability of obstructive sleep apnoea. Br J Anaesth. 2012;108(5):768–775. doi:10.1093/bja/aes022 [PubMed: 22401881]
18. Chung F, Abdullah HR, Liao P. Stop-bang questionnaire: A practical approach to screen for obstructive sleep apnea. Chest. 2016;149(3):631–638. doi:10.1378/chest.15-0903 [PubMed: 26378880]
19. Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. Anesthesiology. 2008;108(5):812–821. doi:10.1097/ALN.0b013e31816d83e4 [PubMed: 18431116]
20. Silva GE, Vana KD, Goodwin JL, Sherrill DL, Quan SF. Identification of patients with sleep disordered breathing: comparing the four-variable screening tool, STOP, STOP-Bang, and Epworth Sleepiness Scales. J Clin Sleep Med JCSM Off Publ Am Acad Sleep Med. 2011;7(5):467–472. doi:10.5664/JCSM.1308
21. Chung F, Chau E, Yang Y, Liao P, Hall R, Mokhlesi B. Serum bicarbonate level improves specificity of STOP-Bang screening for obstructive sleep apnea. Chest. 2013;143(5):1284–1293. doi:10.1378/chest.12-1132 [PubMed: 23238577]
22. R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria 2013 ISBN 3-900051-07-0; 2014. http://www.R-project.org/.
23. Mudambi L, Spiegelman A, Geron D, et al. Obstructive Sleep Apnea is Not Associated with Higher Health Care Utilization after Colonoscopy under Conscious Sedation. Ann Am Thorac Soc. 2 2016. doi:10.1513/AnnalsATS.201510-664OC
24. Corso RM, Piraccini E, Agnoletti V, et al. Clinical use of the STOP-BANG questionnaire in patients undergoing sedation for endoscopic procedures. Minerva Anestesiol. 2012;78(1):109–10. [PubMed: 22071566]

Table 1.

STOP-Bang questionnaire: 1 point given for each positive answer

Snoring loudly (louder than talking)
Tired, fatigued, or sleepy during the daytime
Observed apneas
Pressure – diagnosed or treated
BMI > 35
Age > 50
Neck circumference > 16 inches (40 cm)
Gender: male

Table 2.

Baseline participant characteristics

	Overall (n=223)	STOP-BANG <3 (n=87)	STOP-BANG ≥3 (n=136)	p-value
Participant Characteristics				
Age	61.1 (15.5)	**54.7 (17.7)**	**65.3 (12.4)**	**<0.001**
Female	113 (50.7%)	**63 (72.4%)**	**50 (36.8%)**	**<0.001**
Inpatient status	101 (45.3%)	43 (49.4%)	58 (42.6%)	0.39
Body mass index	26.9 (7.1)	**24.4 (5.3)**	**28.5 (7.6)**	**<0.001**
Bicarbonate	27.2 (3.5)	27.4 (3.3)	27.1 (3.6)	0.57
Baseline oxygen (lpm)	2.0 [2.0, 2.0]	2.0 [2.0, 2.0]	2.0 [2.0, 2.0]	0.47
Past Medical History				
CAD	48 (21.5%)	12 (13.8%)	36 (26.5%)	**0.04**
Heart failure	18 (8.1%)	3 (3.4%)	15 (11.0%)	0.08
Atrial fibrillation/flutter	25 (11.2%)	6 (6.9%)	19 (14.0%)	0.16
COPD	63 (28.3%)	18 (20.7%)	45 (33.1%)	0.06
Asthma	14 (6.3%)	5 (5.7%)	9 (6.6%)	>0.99
Interstitial lung disease	13 (5.8%)	5 (5.7%)	8 (5.9%)	>0.99
Renal disease *	30 (13.5%)	9 (10.3%)	21 (15.4%)	0.38
Home Medications				
Benzodiazepine	27 (12.1%)	14 (16.1%)	13 (9.6%)	0.21
Opioid	39 (17.5%)	17 (19.5%)	22 (16.2%)	0.64
Bronchoscopic Factors				
Procedure types performed:				
Bronchoalveolar lavage	140 (62.8%)	58 (66.7%)	82 (60.3%)	0.41
Microscopy brush	55 (24.7%)	21 (24.1%)	34 (25.0%)	>0.99
Cytology brush	36 (16.1%)	14 (16.1%)	22 (16.2%)	>0.99
Endobronchial biopsy	91 (40.8%)	35 (40.2%)	56 (41.2%)	>0.99
Endobronchial ultrasound	101 (45.3%)	36 (41.4%)	65 (47.8%)	0.42
Interventional bronchoscopy	8 (3.6%)	4 (4.6%)	4 (2.9%)	0.71
Total number of different procedure types performed	2.4 (1.4)	2.4 (1.4)	2.4 (1.4)	0.74
Procedural medications:				
Fentanyl dose (mcg)	100. [75, 175]	113 [75, 188]	100 [75, 150]	0.37
Midazolam dose (mg)	5.0 [4.0, 8.0]	6.0 [4.0, 9.0]	5.0 [3.0, 8.0]	0.20
Procedure duration (min)	30. [16, 58]	30. [16, 54]	31. [16, 65]	0.55

CAD = coronary artery disease, COPD = chronic obstructive pulmonary disease, lpm = liters per minute

* Renal disease defined as GFR < 60.

Data shown as mean +/− standard deviation, median [interquartile range], or N(%). P-values for continuous variables are from an t-test for normally distributed variables, a Kruskal Wallis test for non-normal data. Categorical variable p-values are from a chi-square test for homogeneity.

Table 3.

Univariate associations between bronchoscopy variables and composite immediate respiratory complications

	Odds Ratio (95% confidence interval)
Participant Characteristics	
Age (per decade)	**1.32 (1.09 – 1.61)**
Female sex	1.52 (0.88 – 2.63)
Inpatient status	0.85 (0.49 – 1.47)
Body mass index (kg/m^2)	1.01 (0.97 – 1.04)
Bicarbonate level	1.04 (0.97 – 1.13)
Baseline oxygen (per liter per minute)	**1.39 (1.09 – 1.83)**
STOP-BANG	
Continuous (per 1 point increase)	1.07 (0.92 – 1.25)
Score ≥3 vs. <3	0.98 (0.56 – 1.72)
Score ≥5 vs. <3	1.04 (0.50 – 2.12)
Score ≥3 + bicarbonate ≥28 vs. <3	1.01 (0.51 – 1.96)
Past Medical History	
Coronary artery disease	1.72 (0.90 – 3.29)
Heart failure	0.81 (0.27 – 2.19)
Atrial fibrillation/flutter	0.92 (0.37-2.15)
Chronic obstructive lung disease	1.13 (0.61 – 2.04)
Asthma	**0.26 (0.04 – 0.98)**
Interstitial lung disease	0.48 (0.10 – 1.62)
Renal disease*	1.54 (0.70 – 3.34)
Medications	
Benzodiazepine	0.54 (0.20 – 1.29)
Opioid	1.19 (0.58 – 2.39)
Bronchoscopic Factors	
Bronchoscopy procedure types performed:	
Bronchoalveolar lavage	0.87 (0.50 – 1.52)
Microscopy brush	1.03 (0.54 – 1.92)
Cytology brush	1.06 (0.50 – 2.19)
Endobronchial biopsy	1.06 (0.61 – 1.83)
Endobronchial ultrasound	**2.34 (1.35 – 4.10)**
Interventional bronchoscopy	0.99 (0.20 – 4.15)
Total number of different procedure types performed	**1.24 (1.01 – 1.51)**
Procedural medications:	
Fentanyl dose (per 25 mcg)	1.09 (0.99 – 1.20)
Midazolam dose (per 1 mg)	1.05 (0.96 – 1.14)
Procedure duration (per 10 minutes)	**1.21 (1.10 – 1.34)**

Table 4.

Multivariable model of composite respiratory complications after lasso variable selection

	Odds Ratio (95% confidence interval)
Age (per decade)	**1.28 (1.03 – 1.61)**
Baseline oxygen (per liter per minute)	**1.57 (1.21 – 2.09)**
Bronchoscory duration (per 10 minutes)	**1.20 (1.08 – 1.33)**

Table 5.

Univariate analyses of continuous STOP-BANG for secondary endpoints (odds ration per increase in STOP-BANG by 1 point)

	Odds Ratio (95% confidence interval)
Composite of hypoxemia and bradypnea	1.05 (0.89 – 1.23)
Hypoxemia	1.05 (0.89 – 1.24)
Bradypnea	1.08 (0.75 – 1.51)
Naloxone use	0.85 (0.39 – 1.59)
Jaw lift/chin tilt	1.15 (0.91 – 1.43)
Nasal/oral airway	1.35 (0.84 – 2.15)
Nonrebreather use	1.04 (0.88 – 1.22)
Bag mask ventilation	0.79 (0.40 – 1.39)
Premature procedure end	0.95 (0.57 – 1.47)