Does Difficult Mask Ventilation Predict Obstructive Sleep Apnea? A Prospective Pilot Study to Identify the Prevalence of OSA in Patients with Difficult Mask Ventilation Under General Anesthesia

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Background: Given the pathogenesis of obstructive sleep apnea (OSA), anesthesiologists may be in a unique position to rapidly identify patients who are at risk for undiagnosed OSA in the perioperative period. Identification is the first step in prompt diagnosis and potential prevention of OSA related comorbidities. Patients who exhibit unanticipated difficult mask ventilation (DMV) during induction of general anesthesia may be at risk of having undiagnosed OSA.

Objective: To determine the association of OSA in patients with difficult mask ventilation under general anesthesia.

Methods: Ten patients were identified over a 2-year period at the time of anesthetic induction as being difficult to mask ventilate and were then enrolled in this prospective pilot study. After enrollment and informed consent, the patients were referred to the sleep study center for full overnight polysomnography to evaluate for the presence and severity of OSA.

Results: Of our cohort, 9/10 patients exhibited polysomnographic evidence of OSA, while the last subject tested positive for sleep disordered breathing. Eighty percent (8/10) of subjects espoused snoring, but only 10% (1/10) reported witnessed apneas. Average DMV was 2.5, and higher grades of DMV were associated with more severe OSA.

Conclusion: In this study, difficult mask ventilation was predictive of undiagnosed OSA. Anesthesiologists may be in a unique position to identify patients at risk for OSA and prevention of related comorbidities.

Keywords: Obstructive sleep apnea, difficult mask ventilation
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Obstructive sleep apnea (OSA) is underdiagnosed and undertreated in the United States.¹ Left untreated, patients with OSA, particularly those with more severe disease, may be vulnerable to the development of significant comorbidities,²⁻⁶ many of which may be easier to prevent than to treat. In the perioperative and postoperative periods, OSA patients are at an increased risk for complications (e.g., hypercapnia, hypoxia, and myocardial ischemia).⁷ This is well recognized by the American Society of Anesthesiologists (ASA), which has issued guidelines in an effort to avoid these perioperative complications.⁸ Improvements in our ability to diagnose OSA prior to surgery would help ensure that patients with the disease have the appropriate perioperative precautions to include minimizing or eliminating the use of anesthetic/analgesic agents (e.g., opioids) known to increase the risk of postoperative apnea, escalating the level of postoperative monitoring, and/or applying regional anesthesia rather than general anesthesia where appropriate.

A previous study demonstrated a strong association between patients with difficult intubations and a diagnosis of OSA.⁹ It has also been shown that patients with unanticipated difficult intubations are likely to have OSA.¹⁰ Khetarpal et al. reported an incidence of impossible mask ventilation of 0.15% in an ob-

BRIEF SUMMARY

Current Knowledge/Study Rationale: This study was undertaken to identify the association between difficult mask ventilation under general anesthesia and obstructive sleep apnea (OSA). The characteristics of these two entities often overlap and suggest a similar pathophysiologic pathway.

Study Impact: Anesthesia providers are in a unique position to identify patients at risk for having OSA. The patient with difficult mask ventilation while undergoing general anesthesia may benefit from referral to a sleep center for evaluation of OSA. Early referral, diagnosis and treatment can help prevent or minimize OSA-related co-morbidities.

servational study of over 50,000 general anesthetics.¹¹ A history of OSA was found to be an independent predictor of impossible mask ventilation. An association between difficult mask ventilation (DMV) and OSA has not been defined, but patients with DMV may have excess soft tissue or other airway abnormalities that lead to obstruction similar to patients with OSA.

If DMV is strongly associated with OSA, anesthesia providers would be in a unique position to identify patients with previously undiagnosed disease. One study showed a DMV prevalence of 5% (75 of 1502 patients), but only 13 cases were anticipated

by the anesthesiologist.¹² Using a previously described grading scale (Grade 2—requiring an oral airway or other adjunct, Grade 3—requiring 2-person ventilation, Grade 4—unable to mask ventilate),¹³ Han et al. found a prevalence of 20% of Grade 2 DMV in a population of 1854.¹³ Another study described risk factors associated with difficult mask ventilation.¹⁴ Risks included height, weight, age, male gender, increased Mallampati class, history of snoring, lack of teeth, and presence of beard.

The inability to ventilate easily through a relaxed collapsible upper airway after a patient has been induced with general anesthesia suggests propensity to obstruction that may also become manifest during sleep as a consequence of sleep related muscle relaxation. We hypothesize that DMV suggests the presence of OSA. To our knowledge, this is the first prospective study investigating the association between patients with DMV and OSA.

METHODS

Subjects

This study was approved by the Institutional Review Board at the Walter Reed Army Medical Center. Male and female military health care beneficiaries aged ≥ 18 years presenting with difficult mask ventilation were included for this study. Assuming that the proportion of subjects with difficult mask ventilation who prove to have OSA is 80%, a sample of 60 subjects will provide a 95% confidence interval of 67% to 89%. From 2006 to 2008, patients were identified at the time of anesthetic induction by experienced anesthesia providers (> 1 year of clinical training – anesthesiologist or equivalent CRNA) as being difficult to mask ventilate. Inclusion criteria were $\geq$ Grade 2 DMV.¹³ Patients with prior difficult airway or DMV were excluded to include those with difficult mask ventilation thought to be caused by excessive facial hair or edentulous patients, as well as patients who had previous polysomnography or previous diagnosis of OSA. Patients were referred to one of the primary investigators by the responsible anesthesia provider, and were consented for prospective enrollment in the study. Patient recruitment was achieved through personal communication and departmental meetings.

Procedure

After enrollment, patients were consented and scheduled for full-night or split-night overnight polysomnogram (PSG). Over the 2-year period, 15 patients were referred with $\geq$ Grade 2 DMV. Of those, 10 patients consented and completed an overnight PSG. The following demographic and clinical characteristics were collected: height, weight, age, gender, neck circumference; history of snoring; history of excessive daytime somnolence; witnessed apneas; Mallampati score; thyromental distance; history of difficult mask ventilation or intubation; surgical procedure; past medical and surgical history; and medication history. All patients received midazolam and fentanyl at the discretion of the anesthesia provider, and all were induced with propofol. Mask ventilation was performed prior to administration of a muscle relaxant.

All PSGs were performed using a 16-channel montage (Sensormedics Alpha Somnostar system, Sensormedics, Yorba Linda, CA). PSG consisted of continuous recordings using central and occipital leads, bilateral electrooculograms, submental and

bilateral tibial electromyograms, and electrocardiogram. Nasal and oral airflow were measured using both thermocouple sensors and pressure transducer airflow (PTAF) monitoring devices. Tracheal sounds were monitored using an acoustic microphone. Thoracic and abdominal excursions were measured using inductance plethysmography. Continuous oxygen saturation was assessed using noninvasive pulse oximetry. Studies were scheduled to last between 6 and 8 h and were terminated following the final awakening. PSGs were scored in 30-sec epochs following criteria of Rechtschaffen and Kales for sleep staging.¹⁵ All studies were scored by a registered polysomnography technician. In addition, all studies were reviewed and interpreted by a physician board certified in sleep medicine.

Data Analyses

All subjects were studied after full recovery from surgery and a minimum of 30 days after their operation. The following data were collected: apnea-hypopnea index (AHI), respiratory effort related arousals (RERA), periodic limb movements of sleep, oxygen saturation nadir, and time spent below an oxygen saturation of 90%. Of the 10 patients, one patient had been taking eszopiclone and another had been taking tramadol, diazepam, and Percocet preoperatively.

OSA diagnoses were rendered in concordance with the American Academy of Sleep Medicine guidelines.¹⁶ AHI ≥ 30 was scored as severe OSA, 15 to 30 as moderate OSA, and 5 to 15 as mild OSA. Upper airway resistance syndrome (UARS) was diagnosed by PTAF criteria, with RERAs $> 5/h$ and associated excessive daytime sleepiness. Excessive daytime sleepiness (EDS) was identified by an Epworth Sleepiness Scale (ESS) score ≥ 10 . After diagnosis of OSA or UARS, patients were referred to a sleep specialist for discussion and treatment of OSA.

RESULTS

Ten of 15 patients identified as candidates for this study were enrolled. Ten patients completed PSG testing and composed our cohort. Of the patients who were not enrolled, 3 lived outside our coverage area and thus were not included, and 2 did not complete the polysomnography.

The subjects in our study underwent a variety of surgeries, including thyroidectomy (3), prostatectomy (2), spinal surgery (2), ureteroscopy (1), coronary artery bypass surgery (1), and melanoma excision from an extremity (1). Average time between surgery and PSG was 7 months and 2 days. Maximum time was 21 months, and 8 of 10 patients received their PSG within 6 months of surgery. Their physical, historical, airway, and PSG data are presented in **Tables 1, 2, and 3**, respectively.

Sixty percent of subjects were male; average age for the cohort was 48 years (range 28-72 years). Nine patients were overweight or obese, with a mean BMI of 34.4 (range 23.1-44.8) for the entire group. Average BMI was 34.1 at time of surgery and 33.9 at time of PSG. Epworth Sleepiness Scale scores averaged 9 (range 3-14), with 4 patients scoring in the unequivocally sleepy range.

Eight of 10 (80%) subjects had a history of snoring, but only 1/10 (10%) reported witnessed apneas. Sixty percent of patients had a history of hypertension.

Table 1—Physical characteristics

Subject	Age	Gender	Body Mass Index	Neck Circumference (inches)	Mallampati Score	Thyromental Distance	Epworth Sleepiness Scale
1	43	M	42.2	19.0	2	3	5
2	26	M	31.5	18.0	2	4	11
3	51	F	38.0	17.0	2	4	3
4	72	M	33.3	18.0	2	3	14
5	61	M	33.7	18.0	2	3	11
6	45	F	29.3	16.5	1	3	8
7	51	M	30.0	18.0	1	3	7
8	48	M	23.1		1	3	9
9	54	F	44.8		2	3	
10	28	F	38.0	15.5	1	3	13
Mean	48		34.4	17.5	1.6	3.2	9

Table 2—Historical characteristics

Subject	Snoring	Witnessed Apneas	Headache	GERD	ED	HTN	Diabetes Mellitus	CAD	Thyroid Disease
1	+	-	+	-	+	+	+	-	-
2	+	-	-	-	-	+	-	-	+
3	+	-	-	-	-	+	-	-	+
4	+	+	-	-	+	+	-	-	-
5	+	-	-	-	-	+	-	-	-
6	+	-	-	-	-	-	-	-	+
7	+	-	-	+	+	+	-	+	-
8	-	-	-	-	-	-	-	-	-
9	+	-	-	-	-	-	-	-	-
10	-	-	+	-	-	-	-	-	-
Percent	80	10	20	10	30	60	10	10	30

Table 3—Airway grades and polysomnographic characteristics

Subject	OSA Severity	DMV Grade	Intubation Grade	AHI	TAI	%time < 90% O ₂ sat	Low oxy	TST Diagnostic
1	Severe	3	1	61.2	47	53.1	23	172
2	Severe	3	1	50.7	23	3.9	86	184
3	Severe	3	1	90.3	62	38.2	65	115
4	Severe	2	2	59.2	83	8.7	66	319
5	Severe	3	Elective fiberoptic	63.4	43.2	48.7		
6	Moderate	2	1	18	11		72	198
7	Moderate	3	1	15.6	24	3.3	83	308
8	Mild	2	1	10.4	17	5.6	83	294
9	Mild	2	4	11.3	35.8		80	388.5
10	UARS	2	2	4	22	2	93	334
Mean		2.5	1.56	38.4	36.3	20.4	72.3	271.0

DMV grades on anesthesia induction were all > 2 and averaged 2.5. Interestingly, DMV was only mildly associated with difficult intubation. Though not powered to detect this, higher grades of DMV were associated with more severe OSA.

PSG data universally showed sleep disordered breathing among our cohort. Five subjects had severe OSA, 3 had moder-

ate OSA, one had mild OSA, and one had UARS. Subjects had an average AHI of 38.4 and a mean percent of time below an oxygen saturation of 90% of 20%, indicative of clinically significant disease. On medication review, only the 2 subjects who underwent spinal surgery had access to medications (narcotics, hypnotics) that could contribute to sleep disordered breathing,

but both patients denied taking these medications prior to and on the day of the PSG.

DISCUSSION

The specific aim of this study was to identify patients who exhibited DMV upon induction of general anesthesia and then determine whether or not they had OSA. Consistent with our hypothesis, all subjects in our pilot study were identified as having SDB. Furthermore, increasingly difficult DMV appeared to be associated with more severe SDB.

Although OSA is very common,¹⁷ the majority of patients presenting to the operating room with OSA have not previously been diagnosed. Anesthesia providers may be in a unique position to identify patients at risk for OSA. The anesthesia airway exam is useful in predicting difficulty with intubation, which in turn has been associated with the presence of OSA.^{9,10} Difficult mask ventilation occurs more commonly than difficult intubation and is often present despite a normal airway exam and in the absence of difficult intubation. In a study by Langeron et al., only 13 of 75 difficult mask ventilation patients were anticipated by the anesthesiologist.¹² Interestingly, in our study the degree of DMV did not seem to correlate well with grade of intubation, suggesting that the mechanism for obstruction in DMV may be different from that of difficult intubation. Admittedly, high Mallampati score and short thyromental distance may have been selected out of our cohort, as these patients may be more likely to have an elective awake fiberoptic intubation and thus avoid mask ventilation.

Our study population had some characteristics suggestive of OSA. Subjects had an elevated BMI, large neck circumference, higher prevalence of snoring and hypertension than the overall population, and higher ESS scores than normal. Telltale signs of OSA such as witnessed apneas were lacking. Further analysis utilizing predictive models for OSA showed that 80% of our patients with sleep disordered breathing would have been identified by the STOP questionnaire used by Chung et al.,¹⁸ and 80% by the Berlin questionnaire.¹⁹ The STOP questionnaire missed a patient with moderate OSA and a patient with UARS (similar to what would be expected based on the validation study of this questionnaire). The Berlin questionnaire performed similar to expectation, missing one moderate OSA and one mild OSA. Given the strong pretest probability of OSA among patients who have snoring and witnessed apneas, the importance of using DMV as a referral criterion for polysomnogram is further strengthened.

Neck masses, in general, may cause concern for DMV and difficult intubation. Three of our subjects underwent thyroidectomies, but none had preoperative signs or symptoms of airway compromise. Additionally, one may postulate that removal of excess thyroid tissue would improve airway patency, making PSGs more likely to be normal. Interestingly, all 3 patients with thyroid disease in our cohort had SDB on PSG despite thyroidectomy.

There are several limitations to this study. The sample size was small. It is probable that other patients demonstrated DMV, but were not referred to the investigators. Despite multiple departmental meetings and personal communications describing

our recruitment process, a total of only 15 patients were identified. However, the high prevalence of clinically significant SDB makes it unlikely that a larger study would markedly change our results. Also, there was no control group. It is difficult to know how many patients without DMV also would have been diagnosed with OSA. If the prevalence of undiagnosed sleep apnea is as high as has been previously described,¹ it is possible those without DMV would also exhibit OSA. A more thorough investigation could have compared our cohort to matched controls with Grade 1 mask ventilation. Given the demand for access to overnight polysomnography at our institution, screening this group of patients would have proved challenging. Despite this study's limitations, we feel that the results are compelling enough to warrant further study with an expanded DMV group as well as a normal control group.

In conclusion, this pilot study demonstrated that DMV (Grade 2 or higher), even in the absence of difficult intubation or non-reassuring airway exam, was a strong predictor of OSA. As the ASA continues to emphasize the importance of providing full perioperative care,²⁰ and as the role of the anesthesiologist continues to expand into the postoperative period, this study serves two purposes. First, the identification and treatment of patients at risk for OSA may improve or prevent the comorbidities associated with this disease process. The anesthesia provider is in a unique position to witness DMV and thus refer patients appropriately to sleep medicine physicians for definitive diagnosis and treatment. Second, it allows the provider to develop an anesthetic plan to provide optimal perioperative and postoperative management for a patient with a likely diagnosis of OSA.

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