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Risk factors for overnight respiratory events following sedation for magnetic resonance imaging in children with sleep apnea

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Abstract

Purpose—Children with sleep apnea may be at increased risk for overnight respiratory events (ORE) following anesthesia. We sought to identify ORE risk factors in sleep apnea patients sedated for magnetic resonance imaging (MRI).

Methods—One thousand four hundred seven hospitalizations for children with sleep apnea (by ICD-9 code) occurred at our institution from 5/1/2011 to 2/1/2015. One hundred twenty-seven (9 %) encounters were solely for post-MRI observation representing 96 unique patients. The first post-MRI admission for each patient underwent chart review. ORE was defined as sustained oxygen saturation <90 % with need for increased oxygen or adjustment of respiratory support after release from recovery. Characteristics of patients with and without ORE were compared by chi-squared analysis or independent samples *t* test. Logistic regression identified associations with ORE.

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Contributor statements

Dr. Trost coordinated and supervised data collection, drafted the initial manuscript, and approved the final manuscript as submitted.
Drs Cowell, Cannon, Mitchell, Waloff, and Mr. Avila contributed to study design, carried out data collection, reviewed and revised the manuscript, and approved the final manuscript as submitted.
Mr. Chand assisted with statistical data analysis and edited the methods and results.
Dr. Russell guided the study design, critically reviewed the manuscript, and approved the final manuscript as submitted.

Compliance with ethical standards

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Conflict of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements) or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval

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.

Informed consent

Informed consent was not obtained from all individual participants included in the study because a database was used and no identifying characteristics were recorded. All studies were approved by the investigator's institutional review board.

Results—Ten out of 96 (10.4 %) patients had ORE. The average time following sedation to ORE was 10.25 h. ORE patients were hospitalized longer (median 2 vs. 1 day, $p < 0.001$). Overall, patients were 55 % male, 60 % Hispanic, with median age of 5 years [IQR 2–10] and median body mass index (BMI) of 17.9 [IQR 15.2–24]. On logistic regression, apnea-hypopnea index (AHI; OR 1.007 [95 % CI 1.002–1.011]), anesthesia complication (OR 1.13 [95 % CI 1.01–1.28]), and home non-invasive positive pressure ventilation (NIV; OR 6.08 [95 % CI 1.57–26.17]) were associated with ORE.

Conclusion—Ninety percent of children with sleep apnea admitted for overnight observation following sedated MRI did not have an ORE. AHI, anesthesia complications, and NIV use may help target higher-risk patients and avoid unnecessary hospitalizations.

Keywords

Sleep apnea; Sedation; Anesthesia; Ventilation

Introduction

Sleep apnea, attributed to obstructive and central etiologies, affects 1–6 % of children [1]. Children with sleep apnea may have respiratory problems during procedural sedation. 1.4–23% of children undergoing adenotonsillectomy to treat sleep apnea experience respiratory compromise, with the wide range owing to differences in comorbidities, age, and event definition [2, 3]. Because events may occur well after surgery, otorhinolaryngologists and anesthesiologists endorse overnight observation following adenotonsillectomy in the highest risk group: those with an apnea-hypopnea index (AHI) >10 or age <3 years [4]. However, sedation for non-surgical procedures is increasing and quality evidence on the risks for and frequency of adverse events in this setting is lacking [5–7]. Should a child with sleep apnea be hospitalized overnight following sedation for magnetic resonance imaging (MRI)?

In 2011 at Children's Hospital Los Angeles (CHLA), a consensus group of anesthesiologists and pulmonologists determined guidelines for non-invasive procedural sedation in children with sleep apnea. For children undergoing sedation for imaging studies, the panel recommended admission for patients with severe sleep apnea (AHI ≥10) and patients with any severity or presumed sleep apnea in the presence of a major comorbidity (obesity, craniofacial anomalies, severe asthma, congenital heart disease, neuromuscular disease, down syndrome, anatomic nasal obstruction, or grades 3–4 tonsils). Patients admitted for this reason were followed by hospitalists or residents with additional inpatient pulmonary consultation in the case of advanced respiratory support (bi-level or continuous non-invasive positive pressure ventilation; NIV). This level of resource utilization despite limited evidence on rates of overnight respiratory events (ORE) was questioned. Therefore, we sought to establish the rate of ORE in this population since guidelines were established. We hypothesized ORE was a rare event and hospital admissions could potentially be avoided. We additionally hypothesized certain factors might increase the risk of children with sleep apnea having ORE, and recognition of these factors could allow more targeted admissions.

Methods

Study design

We conducted a retrospective chart review at CHLA, a large urban tertiary freestanding pediatric hospital. Patients admitted between 5/1/2011 and 2/1/2015 with an international classification of diseases (ICD-9) diagnosis code indicating sleep apnea (obstructive, central, or otherwise unspecified sleep apnea: 780.57, 786.09, 327.22, 780.53, 327.23, 327.20, 327.29, 327.21, 327.27) were eligible for inclusion (n = 1407). Eligible patients' history and physicals (H+P) were manually screened, identifying 127 (9 %) patients admitted solely for observation following MRI. Since multiple patients were admitted more than once for this reason during the study period, only the first admission underwent chart review, representing 96 unique patients. Study procedures were approved by the CHLA Institutional Review Board.

Data collection

Six independent researchers reviewed charts to extract potential risk factors (demographics, comorbidities, home medications, usual level of respiratory support), characteristics of sedation (medications, duration sedated, peri-anesthesia complications), and outcomes during hospitalization (ORE, time to ORE, ICU transfer, length of stay). ORE was defined as sustained oxygen desaturation <90 % for which their primary provider increased oxygen or adjusted respiratory support after release from anesthesia recovery. Comorbidities were defined as an additional diagnosis in any of eight body systems mentioned in the H+P. Complications were as recorded by the anesthesiologist. Study data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools hosted at the University of Southern California [8]. Before final data collection, researchers were trained and tested on a subset of charts to obtain inter-rater reliability (kappa = 0.932).

Statistical analysis

Characteristics of patients with and without ORE were compared by chi-squared analysis or Mann-Whitney U. Logistic regression identified associations with ORE. Due to missing AHI values in anesthesia H+Ps for 16 (17.5 %) patients; last value carried forward imputation was performed to verify associations. Statistics were performed using SPSS (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.).

Results

The 96 patients were 55 % male, 60 % Hispanic, with median age of 5 years [IQR 2–10] and median body mass index (BMI) of 17.9 [IQR 15.2–24]. Patients were generally medically complex; 67 (69 %) had comorbidities in 4 or more body systems. 90.7 % of patients were sedated with propofol and 32.9 % received sevoflurane. Procedures lasted an average of 96.4 min (SD ± 41.43 min) and 50 % of patients had some complication during anesthesia. The most common complication was airway manipulation (nasal trumpet=11, laryngeal mask airway=32, chin thrust=3, oral airway=11, intubation= 1). Other anesthesia complications included excess secretions (n = 3), failed extubation (n = 1), hypotension (n = 1), difficult IV

access ($n = 5$), obstruction ($n = 13$), or desaturation during recovery ($n = 1$); 18 patients had more than 1 complication.

Only ten (10.4 %) patients had an ORE and no children died. One patient with NIV and multiple craniofacial anomalies was transferred to the ICU after ORE, primarily as a precaution due to history of difficult intubation. NIV settings were adjusted and the patient went home uneventfully on hospital day 3. Patients with and without ORE were similar in terms of gender, race, history of prematurity, American Society of Anesthesiologists (ASA) physical status classification, comorbidities, home medications, and sedation drug (Table 1). A higher percentage of patients having ORE used NIV at home ($p = 0.011$). Although not statistically significant, patients with ORE had higher BMI, were slightly older, had more comorbidities, and were sedated longer.

On bivariate logistic regression, having an anesthesia complication (OR 1.13 [95% CI 1.01–1.28]) and higher AHI were associated with risk for ORE (OR 1.01 [95 % CI 1.00–1.01]; $p = 0.003$). With last value carried forward, the AHI association remained significant (OR 1.05 [95 % CI 1.01–1.1]; $p = 0.012$). Use of NIV was most strongly associated with ORE (OR 6.08 [95 % CI 1.57–26.17]; $p = 0.009$; Table 2). Patients with older age were more likely to require home NIV (OR 1.03 [95 % CI 1.01–1.04]; $p < 0.001$).

Discussion

In this single-center retrospective review, only 10 % of patients admitted for observation following sedated MRI had ORE. All patients were admitted because they were presumed to be high risk for events. However, our results reveal potential to avoid 90 % of such admissions if more accurate predictive models for identifying high-risk patients are developed. Our descriptive results suggest who these patients may be: older, more complex patients with very high AHI who have already progressed to requiring advanced respiratory support.

Sedation in non-surgical settings is broad in terms of anesthetic agent used and procedure necessitating sedation, making comparisons within literature difficult. Specifically related to pre-radiography sedation, one study of 654 generally healthy (all with ASA ≤2) pediatric patients at a freestanding imaging center found 11.5 % had desaturation and 1.7 % had apnea but all recovered without need for hospitalization [9]. Another study including children sedated for MRI found that older age, higher ASA status, upper respiratory infection, sleep apnea/snoring, and obesity are associated with failed sedation but failure was still a rare event [10]. In both these studies, >90 % of children were sedated with propofol, similar to our population. Another body of literature evaluates drug-induced sedated endoscopy (DISE) to mimic sleeping state and directly identify sites of airway collapse. In children undergoing DISE, propofol has been associated with lower oxygen saturations and higher rates of failed cases compared to other anesthetic regimens. However, the overall success rate was 93 % [11]. Together with our findings, it appears serious adverse events following non-surgical sedation are rare with or without the presence of comorbid sleep apnea.

We identified the strongest association with ORE to be use of home NIV. The number of children receiving NIV at home has grown over the past decade worldwide [12]; however, there are no NIV-specific guidelines for procedural sedation. Anesthesiologists have recommended that patients on continuous NIV are poor candidates for ambulatory sedation programs and should be hospitalized for observation, but are less clear when support is only needed overnight [13]. In our study, all patients' NIV use followed their home routines in the hospital. There were 17 patients who used NIV but did not have ORE. Although NIV itself may not predispose to ORE, it may indicate advanced disease in a truly high-risk patient.

Our study's strengths include high inter-rater reliability on chart reviews and availability of detailed anesthesia pre-procedure H+Ps. However, there were also limitations. Since we do not have access to continuous oxygen levels at home, it is possible that OREs in some patients occur periodically unrelated to sedation. However, the very reason for overnight observation was to monitor for and treat significant desaturations as an unexpected clinical event. The low rate of ORE prevents multivariable modeling to better understand interactions between identified risk factors. Using ICD-9 codes to identify patients may lead to selection bias. In addition, chart review may introduce reporting bias. Finally, the high proportion of patients with complex multisystem illness limits applicability to lower-acuity settings. However, due to the general dearth of information regarding non-operative sedation risks in sleep apnea patients, we feel these data can be of use to other practitioners. Multicenter studies should occur to better target at risk patients and reduce unnecessary admissions and observations.

Conclusion

Ninety percent of children with sleep apnea admitted for overnight observation following sedated MRI did not have an ORE. AHI, anesthesia complication, and home positive pressure ventilation were identified associations with ORE. Targeting the highest risk patients may avoid unnecessary hospitalizations.

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Table 1

Patient characteristics

Variable	Total *N* = 96	No ORE *N* = 86 (89.6 %)	ORE *N* = 10 (10.4 %)	*p* *
Demographics				
Sex				
Male	53 (55.2 %)	49 (57 %)	4 (40 %)	0.335
Female	43 (44.8 %)	37 (43 %)	6 (60 %)	
Gestation				
<34	12 (12.5 %)	11 (12.8 %)	1 (1 %)	0.862
34–36	16 (16.7 %)	15 (17.4 %)	1 (1 %)	
37+	68 (70.8 %)	60 (69.8 %)	8 (80 %)	
Race				
White	23 (24 %)	22 (25.3 %)	2 (20 %)	0.267
Hispanic	58 (60.4 %)	50 (57.5 %)	4 (40 %)	
Other	15 (15.6 %)	15 (17.2 %)	4 (40 %)	
Age, years (median, IQR)	5 (2–10)	5 (2–9)	11 (3–13)	0.057
BMI (median, IQR)	17.92 (15.2–24)	17.6 (15.1–22.1)	19.2 (15.8–31.1)	0.154
Sleep apnea				
AHI (median, IQR)	7.35 (2.62–15.25)	6.65 (2.53–12.5)	15 (5.37–46.5)	0.070
Respiratory support				
Non-positive pressure	73 (76.1 %)	69 (80.2 %)	4 (40 %)	0.011
NIV	23 (23.9 %)	17 (19.8 %)	6 (60 %)	
Comorbidities				
No. of systems affected (median, IQR)	4 (3–6)	4 (3–5)	5 (4–6)	0.179
Anesthesia				
ASA score				
2	17 (17.7 %)	15 (17.4 %)	2 (20 %)	1.000
3	78 (81.4 %)	70 (81.4 %)	8 (80 %)	
Any complication	48 (50 %)	40 (46.5 %)	8 (80 %)	0.091
Obstructed during sedation	12 (12.5 %)	11 (12.8 %)	1 (10 %)	1.000
Needed airway manipulation	45 (46.9 %)	38 (44.2 %)	7 (70 %)	0.182
Mean duration of sedation, minutes	96.4 (±41.43)	94.26 ± 36.45	115.10 ± 65.94	0.350
Hospitalization				
Length of stay (days, median, IQR)	1 (1–1)	1 (1–1)	2 (1–3)	<.001

BMI body mass index, *AHI* apnea-hypopnea index, *NIV* non-invasive ventilation (BPAP or CPAP), *ASA* American Society of Anesthesiologists (ASA) physical status classification

* By Fisher's exact for categorical and Mann-Whitney U for continuous variables

Table 2

Bivariate logistic regression of characteristic association with ORE

Variable	Odds ratio	95 % CI	*p*
Age	1.09	0.98–1.22	0.090
BMI	1.05	0.96–1.14	0.185
AHI	1.01	1.00–1.01	0.003
AHI (imputed)	1.05	1.01–1.1	0.012
NIV	6.18	1.57–24.35	0.009
Comorbidity systems[a]	1.03	0.99–1.07	0.067
Sedation duration	1.01	0.99–1.02	0.132
Anesthesia complication	1.13	1.01–1.28	0.042

BMI body mass index, *AHI* apnea-hypopnea index, *NIV* non-invasive ventilation (BPAP or CPAP)

[a]Number of body systems with comorbidity, continuous variable