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SCIENTIFIC INVESTIGATIONS

Use of the Snoring, Trouble Breathing, Un-Refreshed questionnaire to predict perioperative respiratory adverse events in children

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Study Objectives: The Snoring, Trouble Breathing, Un-Refreshed (STBUR) screening questionnaire has been validated in identifying pediatric surgical patients with symptoms of sleep-disordered breathing who may be at risk of perioperative respiratory adverse events. We sought to assess the performance of the STBUR questionnaire when adjusting for potential confounders such as patient comorbidities or surgical service.

Methods: This was a retrospective cohort study of children aged 2–18 years undergoing elective procedures under general anesthesia over a 3-month period. Procedure specialties included general surgery, urology, orthopedic surgery, neurosurgery, plastic surgery, otolaryngology, dentistry, and gastroenterology. Preoperative STBUR questionnaire responses and perioperative respiratory adverse events were documented prospectively. Multivariate logistic regression was used to quantify associations between preoperative questionnaire responses, other potential risk factors (including age, sex, surgical specialty, comorbidities), and risk of perioperative respiratory adverse events.

Results: Of 555 children, 17% had a positive STBUR screen. The prevalence of perioperative respiratory adverse events with a positive questionnaire screen was significantly greater than with a negative screen (29% vs 9%, respectively; $P < .001$). A positive questionnaire screen was associated with a significantly increased risk of a perioperative respiratory adverse event (adjusted odds ratio 3.47 [95% confidence interval 1.53–7.84], $P = .003$).

Conclusions: A positive screen on the STBUR questionnaire was associated with a 3.5-fold increased risk of perioperative respiratory adverse events in pediatric surgical patients. The STBUR questionnaire should be considered as a routine preoperative screening tool in children undergoing elective procedures.

Keywords: sleep-disordered breathing, sleep apnea, respiratory adverse events, screening questionnaire

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BRIEF SUMMARY

Current Knowledge/Study Rationale: There are no commonly used perioperative screening tools for sleep-disordered breathing in children. The Snoring, Trouble Breathing, Un-Refreshed (STBUR) questionnaire is a screening instrument that has been previously validated, but its use and efficacy have not been broadly replicated.

Study Impact: The current study provides further validation of this questionnaire across multiple surgical specialties. A positive screen on the STBUR questionnaire is associated with an approximately 3.5-fold increased risk of perioperative respiratory adverse events, independent of patient comorbidity and surgical service.

INTRODUCTION

Pediatric sleep-disordered breathing (SDB) is a broad term used to describe a spectrum of symptoms related to resistance of flow in the upper airway. SDB can range in severity from loud breathing to obstructive sleep apnea (OSA). Clinical characteristics of SDB include frequent gasping, open mouth breathing, labored breathing, and failure to thrive. It is estimated that approximately 12% of the pediatric population experiences symptoms consistent with SDB, and approximately 2%–6% are affected by OSA.[1–3] Children with comorbidities such as obesity, Down syndrome, neuromuscular disorders, and craniofacial anomalies have a high prevalence of SDB.[4–8]

Children with severe SDB symptoms may experience a higher incidence of perioperative respiratory adverse events (PRAEs) under general anesthesia, including hypoxia, airway obstruction, and respiratory distress.[9] Approximately 25% of patients presenting for surgery have symptoms of SDB that have not previously been recognized.[10] Unfortunately, routine perioperative screening methods for children with SDB remain minimally explored. Overnight polysomnography is recommended by the American Academy of Sleep Medicine as the gold standard to assess children suspected of having SDB or OSA.[11] However, high cost, limited availability, and the inconvenience to families associated with overnight visits limit widespread polysomnography testing. Thus, exploring alternative methods to screen children undergoing elective surgical procedures under general anesthesia is warranted.

The Snoring, Trouble Breathing, Un-Refreshed (STBUR) questionnaire has previously been validated as a method to identify children with potential SDB. This 5-item questionnaire focuses on evaluating snoring, trouble breathing, and daytime

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sleepiness in children ages 2–18 years undergoing surgical procedures requiring general anesthesia.[12] This study sought to assess the utility of the STBUR questionnaire in identifying pediatric surgical patients in our population who may be at risk of PRAEs. Specifically, the aims of this study were to (1) compare the rate of PRAEs between children with a positive STBUR questionnaire screen and children with a negative screen and (2) determine the independent association between a positive STBUR screen and risk of PRAEs, when adjusting for surgical service and other potential risk factors for SDB.

METHODS

Study design and data sources

This was a retrospective cohort study conducted from October 1, 2017, through December 31, 2017, at the Doernbecher Children's Hospital, a tertiary-care children's hospital. Inclusion criteria were children aged 2–18 years scheduled for elective surgery requiring general anesthesia. Children with a missing STBUR questionnaire or postoperative assessments and those with a tracheostomy or whose procedures were cancelled on the day of surgery were excluded. Survey data including preoperative STBUR questionnaires and postoperative PRAE logs were prospectively collected as part of a quality-improvement initiative and later retrospectively reviewed.

The electronic medical record (Epic Systems Corporation, Verona, WI) was reviewed to extract additional demographic data (ie, age, sex, weight, body mass index), comorbidities, and operative details. Operative details included the date of procedure, surgical service, and type of surgical procedure. The Oregon Health and Science University Institutional Review Board approved this study. As a retrospective study with a relatively large number of patients, the requirement of informed consent was waived.

STBUR questionnaire

STBUR questionnaires were administered by perioperative nurses in the preoperative area during check-in for surgery. The STBUR questionnaire consists of 5 questions with responses of "yes," "no," or "don't know." Three or more "yes" responses suggest an increased risk for PRAEs (**Table 1**).[12]

Table 1—Components of the STBUR questionnaire.

1. While sleeping, does your child SNORE more than half the time?
2. While sleeping, does your child SNORE LOUDLY?
3. While sleeping, does your child have TROUBLE breathing, or struggle to breathe?
4. Have you ever seen your child stop breathing during the night?
5. Does your child wake up feeling unrefreshed in the morning?

Reproduced with permission from **Table 3** in reference 12 (copyright © John Wiley & Sons, Inc). STBUR = Snoring, Trouble Breathing, Un-Refreshed.

Potential risk factors

Services included in the analysis were otolaryngology (divided into adenoidectomy, tonsillectomy, or adenotonsillectomy [ENT/TA] vs non-adenotonsillectomy [ENT non-TA] procedures), neurosurgery, plastic surgery, general surgery, urology, orthopedic surgery, dental, gastroenterology, and other (which included pulmonology, dermatology, ophthalmology, cardiothoracic surgery, cardiology, and oncology). Comorbidities were dichotomized as present or absent and included neuromuscular disorders (including cerebral palsy, spastic quadriplegia, hypotonia, and seizure disorder), craniofacial anomalies, Down syndrome, and other airway or syndromic diagnosis. Obesity was defined as a body mass index percentile ≥ 95, based on the height and weight measurements taken on the day of the patient's procedure. Although patients are routinely screened in the preoperative setting for symptoms of upper respiratory infection, including fever, wheezing, and respiratory distress, there was inconsistent documentation of this screening; therefore, this was not included in our analysis.

PRAEs

Postoperative logs of major and minor PRAEs were completed on the day of the procedure by perioperative nurses in the postanesthesia care unit who were blinded to the results of the preoperative STBUR questionnaires. The anesthesia teams were also blinded to the STBUR questionnaire responses. In order to allow direct comparison of respiratory outcomes, PRAEs were similarly defined as described by Tait et al,[10] including minor and major oxygen desaturation events, airway obstruction, laryngospasm, and bronchospasm. However, our definition differed in that we excluded coughing events (**Table 2**).

Analysis

The association between an STBUR-positive screen and the occurrence of PRAEs was compared using a chi-square test. Univariate and multivariate logistic regression analysis was used to calculate unadjusted and adjusted associations between potential risk factors and PRAEs. For this analysis, patients

Table 2—Perioperative respiratory adverse events.

Oxygen desaturation
Minor: 5%–10% decrease from baseline
Major: > 10% decrease from baseline
Airway obstruction
Minor: corrected with repositioning or placement of an oral/nasal airway
Major: requiring jaw-chin thrust or placement of LMA or ETT
Laryngospasm
Requiring continuous positive airway pressure or muscle relaxant
Bronchospasm
Auscultated wheezing

Adapted with permission from reference 12 (copyright © John Wiley & Sons, Inc). ETT = endotracheal tube, LMA = laryngeal mask airway.

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Table 3—Patient characteristics.

	Values
Total n	555
Age, y	
Mean (SD)	9.1 (4.8)
Median [IQR]	8.6 [4.6–13.1]
Sex	
Male	319 (57)
Female	236 (43)
STBUR score	
0	289 (51)
1	125 (22)
2	58 (10)
3	29 (5)
4	25 (4)
5	43 (8)

Data are presented as n (%) unless otherwise specified. IQR = interquartile range, SD = standard deviation, STBUR = Snoring, Trouble Breathing, Un-Refreshed questionnaire.

with multiple major or minor events documented in a single postoperative period were counted as a single adverse event. A sensitivity analysis was also performed where the analysis was (1) repeated with the same PRAE outcome variable as described by Tait et al[12] and (2) limited to major desaturations (> 10%) and obstructive events requiring aggressive jaw thrust or intubation (ie, excluding minor desaturations, minor obstructive events, coughing, laryngospasm, and bronchospasm). Statistical significance was defined as a P value < .05. A sample size calculation was performed based on available published data, which assumed a 21% rate of positive STBUR screen and rate of PRAEs of 27% and 46% among those with negative screens (STBUR score < 3) and positive screens (STBUR ≥ 3), respectively.[10] With $\alpha = 0.05$ and power = 0.9, we calculated a total sample size of 454 (79 positive screens) needed to detect this difference in rate of PRAEs. All analyses were performed with Stata software version 15 (StataCorp LLC, College Station, TX).

RESULTS

Of 602 children who met initial inclusion criteria, 44 children were subsequently excluded due to incomplete STBUR questionnaires or missing outcome assessments, and 3 were excluded due to presence of a tracheostomy (n = 555). The mean age was 9.12 years, with a slightly higher proportion of males (**Table 3**). Surgical service frequency was greatest in gastroenterology (121, 22%) and ENT/TA (95, 17%). Of those who completed the STBUR questionnaire, 17% screened positive (**Table 3**). Among surgical services, the highest mean STBUR score and the highest rate of a positive screen were for ENT/TA procedures (mean score 3.5 ± 1.5, 75% positive screen), with the second highest score in the ENT/non-TA procedures (mean score 1.1 ± 1.4, 14% positive screen; **Table 3**). All other surgical services had a similar range of STBUR scores < 1 and rate of positive screen < 8%. With respect to respiratory outcome, PRAEs were documented in 68 (12%) patients (**Table 4**). There was a significantly higher rate of PRAEs in children with a positive STBUR screen compared with children with a negative STBUR screen (29% vs 9%, respectively; P < .001; **Table 4**). Among children with PRAEs, 49 (72%) were isolated events, of which minor desaturations were the most common (35 of 49). Among children with multiple events, minor oxygen desaturations and minor obstructions were the most common events (13 of 19, 68% each). The surgical service with the most frequent PRAE was ENT/TA (24, 25%) (**Table 5**).

In univariate logistic regression analysis, significant associations were noted between PRAEs and positive STBUR screen (odds ratio [OR] 4.24; 95% confidence interval [CI], 2.46–7.32), airway diagnosis (OR 2.52; 95% CI, 1.39–4.54), and ENT/TA service (OR 6.42; 95% CI, 1.84–22.4). An inverse association was noted between increasing age in years and PRAEs (OR 0.90; 95% CI, 0.85–0.96; **Table 6**). After adjusting for potential confounders, the association between positive STBUR screen and PRAEs remained robust (OR 3.47; 95% CI, 1.53–7.84) as did the association with the ENT/TA service (OR 5.42; 95% CI, 1.52–19.27) and the inverse association with increasing age (OR 0.92; 95% CI, 0.86–0.98; **Table 6**). Sensitivity analysis was performed with regression models using different PRAE outcome variables (ie, including coughing events as described by Tait et al[12], or limited to major desaturation or obstructive events requiring intervention) and did not yield substantially different

Table 4—STBUR screening and perioperative respiratory adverse events.

	STBUR Negative	STBUR Positive	Total
No PRAEs	418 (91)	69 (71)	487 (88)
PRAEs	40 (9)	28 (29)	68 (12)
Major event*	8 (2)	8 (8)	16 (3)
Total	458	97	555

Data are presented as n (%) unless otherwise specified. P < .001 (chi-square), column percentages. *Defined as major desaturation or major obstructive event. PRAE = perioperative respiratory adverse event, STBUR = Snoring, Trouble Breathing, Un-Refreshed questionnaire, STBUR negative = no sleep-disordered breathing.

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Table 5—STBUR scores and PRAEs by surgical service and patient comorbidities.

	n (%)*	STBUR Score, Mean (SD)	Positive STBUR Screen, n (%)	PRAEs, n (%)
Surgical service				
ENT (TA)	95 (17)	3.5 (1.5)	71 (75)	24 (25)
ENT (non-TA)	78 (14)	1.1 (1.4)	11 (14)	9 (12)
Plastics	24 (4)	0.5 (1.1)	1 (4)	3 (13)
General surgery	45 (8)	0.4 (0.7)	1 (2)	4 (9)
Neurosurgery	29 (5)	0.6 (1.0)	2 (6)	5 (17)
Urology	60 (11)	0.3 (0.7)	1 (2)	3 (5)
Orthopedic surgery	43 (8)	0.5 (0.8)	1 (2)	6 (14)
Dental	43 (8)	0.9 (1.1)	3 (7)	6 (14)
Gastroenterology	121 (22)	0.7 (0.9)	5 (4)	7 (6)
Other**	17 (3)	0.3 (0.8)	1 (5)	1 (6)
Comorbidities				
Obesity	102 (19)	1.6 (1.8)	30 (29)	14 (14)
Neurologic disorder	60 (11)	1.2 (1.5)	10 (16)	12 (20)
Craniofacial anomaly	50 (9)	1.4 (1.8)	14 (27)	9 (18)
Down syndrome	10 (2)	1.3 (1.2)	1 (10)	3 (30)
Other airway diagnosis***	84 (15)	1.8 (1.8)	27 (32)	19 (23)
Total	555	1.1 (1.6)	97 (17)	68

*Column percentages. **Includes dermatology, pulmonology, and cardiology. ***Other airway includes OSA, asthma, dysphagia, tonsillar hypertrophy, adenoid hypertrophy, and laryngomalacia. ENT = ear, nose, throat, OSA = obstructive sleep apnea, PRAE = perioperative respiratory adverse event, SD = standard deviation, STBUR = Snoring, Trouble Breathing, Un-Refreshed questionnaire, TA = tonsillectomy with or without adenoidectomy.

results (results not shown). A similar analysis of the relationship between PRAEs and the STBUR score as an ordinal variable rather than a dichotomous variable demonstrated increasing risk of a PRAE with each 1-unit increase in STBUR score (unadjusted OR 1.44; 95% CI, 1.26–1.66; adjusted OR 1.39; 95% CI, 1.13–1.7). A secondary analysis excluding ENT procedures from the regression model also yielded a similar adjusted association between a positive STBUR screen and PRAEs (OR 4.37; 95% CI, 1.13–16.8).

DISCUSSION

Most studies of perioperative sleep apnea–related respiratory complications focus on adult perioperative assessment. However, recent efforts have been made toward improving perioperative evaluation in children. In this study, children were approximately 3.5 times more likely to experience PRAEs when screening positive on the STBUR questionnaire, which is consistent with the results of the original validation study.[10] This relationship persists even with a slightly more restrictive definition of PRAE and after adjusting for surgical service, comorbidities, and other potential confounders. Furthermore, we noted that each 1-unit increase in the STBUR score increased the risk of PRAEs by approximately 39%. These results reinforce the findings of earlier studies demonstrating that the STBUR questionnaire is an effective tool in screening for undiagnosed SDB and helping to identify children at increased risk of PRAEs across a broad range of surgical services.

Tait et al in 2013 developed the 5-item STBUR questionnaire as a subset of the 22-item Pediatric Sleep Questionnaire–Sleep Related Breathing Disorder scale (PSQ-SRBD) screening questionnaire.[12] They demonstrated a 3-fold increased risk of PRAEs with 3 or more positive responses in a cohort of 337 children. In 2016, the same group found an approximately 2-fold increased risk of PRAEs in a larger cohort of 678 children.[10] After electronic implementation of the STBUR, Terry et al[13] in 2016 successfully increased the identification of children at risk for PRAEs, allowing for proper perioperative management. More recently, Galvez et al[14] have noted that lack of positive responses on the STBUR (score = 0) demonstrates a high negative-predictive value for need for supplemental oxygen, extended post-anesthesia care unit stay, or escalation of care. They noted that the STBUR could therefore potentially be used to screen for children at low risk of perioperative respiratory morbidity. However, these findings have not been broadly replicated at other institutions, nor has there been any attempt to adjust for surgical service or comorbidities that could influence the prevalence of PRAEs.

In this study, it is not surprising that, among the surgical services, children undergoing tonsillectomy with or without adenoidectomy had the strongest association with PRAEs and the highest rate of STBUR-positive screens. Most of these patients were specifically being treated for SDB or OSA, a known risk factor for perioperative morbidity.[15–17] Our finding of an inverse relationship

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Table 6—Association of PRAEs and patient risk factors.

Risk Factor	Unadjusted OR [95% CI]	*P*	Adjusted OR† [95% CI]	*P*
Age, y	0.90 [0.85–0.96]	.001	0.92 [0.86–0.98]	.02
Sex	0.82 [0.49–1.37]	.45	—	
Obesity	1.17 [0.62–2.20]	.63	—	
Neuromuscular disorder	1.96 [0.98–3.91]	.06	1.41 [0.61–3.24]	.42
Craniofacial anomaly	1.66 [0.77–3.59]	.20	1.19 [0.48–2.95]	.71
Down syndrome	3.16 [0.80–12.54]	.10	2.94 [0.63–13.59]	.17
Other airway diagnosis*	2.52 [1.39–4.54]	.002	1.78 [0.93–3.43]	.08
Surgery service				
Urology	Reference		Reference	
General surgery	1.85 [0.39–8.73]	.44	2.07 [0.43–9.88]	.36
Plastic surgery	2.71 [0.51–14.5]	.24	2.64 [0.46–15.28]	.28
Orthopedic surgery	3.08 [0.73–13.1]	.13	3.43 [0.78–14.99]	.10
Neurosurgery	3.96 [0.88–17.9]	.07	3.73 [0.77–18.16]	.10
Gastroenterology	1.17 [0.29–4.68]	.83	1.66 [0.39–6.97]	.49
Dental	3.08 [0.73–13.1]	.13	2.66 [0.61–11.57]	.19
ENT (non-TA)	2.48 [0.64–9.59]	.19	1.91 [0.48–7.59]	.36
ENT (TA, A, T)	6.42 [1.84–22.4]	.004	5.42 [1.52–19.27]	.009
Other**	1.19 [0.12–12.2]	.89	1.01 [0.10–10.65]	.99
STBUR positive screen	4.24 [2.46–7.32]	<.001	3.47 [1.53–7.84]	.003

*Includes OSA, asthma, dysphagia, tonsillar hypertrophy, adenoid hypertrophy, laryngomalacia. **Includes ophthalmology, dermatology, pulmonology, cardiac surgery. †Sex and obesity were dropped from multivariable models due to lack of association in univariate regression. Multivariable model for STBUR positive screen includes all other covariates in the column. Multivariable models for other variables include all covariates except for STBUR positive screen. A = adenoidectomy, CI = confidence interval, ENT = ear, nose, throat, Obesity = ≥ 95th percentile based on body mass index, OR = odds ratio, OSA = obstructive sleep apnea, *P* = level of marginal significance, PRAE = perioperative respiratory adverse event, Reference = urology with lowest mean STBUR score, STBUR = Snoring, Trouble Breathing, Un-Refreshed questionnaire, T = tonsillectomy, TA = tonsillectomy with or without adenoidectomy.

between increasing age and PRAEs is consistent with previous studies demonstrating greater risk of respiratory morbidity in younger children.[18,19] It is interesting that comorbidities often associated with increased risk of perioperative respiratory morbidity, such as neuromuscular disorders, craniofacial anomalies, or Down syndrome, were not found to be significantly associated with PRAEs in the current study. This may reflect the broad spectrum of severity associated with these comorbidities and suggests that relying on comorbidity alone as a predictor of respiratory morbidity may not be as accurate or as efficient as using a validated screening instrument like the STBUR. It is worth noting that the point estimates of association all suggest an increased risk of PRAEs with these comorbidities, but it may be that the lack of statistical significance reflects the relatively small numbers in these subgroups. Another interesting observation is that children with "other airway diagnoses," which includes OSA and adenotonsillar hypertrophy, also did not quite reach statistical significance in adjusted analysis, even though there was a strong association in unadjusted analysis. As with the other comorbidities, the adjusted point estimate does suggest a positive association with PRAEs, but the strength of association may be partially blunted by adjustment for surgical service including ENT. It is unclear why the association between a positive STBUR screen and PRAEs increased when the ENT service was excluded from the analysis. This may reflect an expectation of greater potential for PRAEs among ENT patients, leading to more preventive efforts (eg, observing for longer periods after extubation before transferring to the post-anesthesia care unit or use of supportive treatments like a nasopharyngeal airway) among ENT patients compared with those on other services where undiagnosed SDB or OSA would not be anticipated.

The rate of a positive STBUR screen among our pediatric population was substantial (17%). Considering how frequently children present for surgery with undiagnosed SDB or OSA, we would support the routine use of a screening questionnaire in preoperative assessment. The frequency of screening for SDB or OSA by anesthesia providers is typically higher in children with known SDB symptoms or those undergoing adenotonsillectomy, but lower in children with undiagnosed SDB or those undergoing nonairway procedures.[17] Given this observation, children with no previous history of SDB may benefit the most from a validated perioperative screening instrument. It is then reasonable to consider the implementation of the STBUR questionnaire as a routine SDB screening tool.

Strengths of the current study include the prospective administration of the STBUR and documentation of PRAEs, as well as acquisition of data from multiple surgical specialties, which increases the generalizability of our findings. In addition, perioperative nurses evaluating respiratory outcomes were blinded

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to the results of the STBUR questionnaire, eliminating this potential bias in outcome assessment.

However, there are also important limitations. First, the interpretation of PRAEs is subjective and contingent upon expertise and experience of the nurses involved. It is possible that their assessments could have been biased by other factors for which we did not account, such as the type of surgery performed or prior diagnosis of OSA. Second, despite efforts to standardize the methods of data collection, since outcome assessment was assigned to perioperative nurses with full-time clinical duties rather than dedicated research assistants, it is possible that the postoperative assessments were not always documented consistently, increasing the possibility for inaccurate recall even when surveys were completed immediately after patient discharge from the perioperative area. Third, our analysis grouped adverse events into loose categories of major and minor and the overall analysis collapsed these into a single dichotomous outcome. This did not account for multiple adverse events within a single postoperative period, potentially underestimating the severity of some events. It is possible that this could have biased some of our observed associations. However, the designations of major and minor adverse events did not necessarily reflect increased or persistent morbidity beyond the immediate postoperative period; therefore, the clinical significance of multiple events as defined in this study is unclear. Fourth, we did not attempt to adjust for specific details of each case, such as the type of procedure, anesthesia, or analgesia used. In general, most patients are treated with inhaled anesthetic with propofol and opioid used as needed. Total intravenous anesthetic was rarely used, except for bronchoscopies after an inhalational induction. This study was not designed to assess these case-specific variables, and the heterogeneity of specific procedures across the different surgical services made it difficult to analyze the impact of procedure type on the incidence of PRAEs. It is possible that these variables could be additional sources of confounding and should be investigated in future studies. Last, our findings represent a single institution over a relatively short 3-month time period. Although they are consistent with the findings of previous studies investigating the use of the STBUR questionnaire, future studies should include data from multiple institutions over a longer time frame to determine whether similar patterns are observed. In particular, the utility of screening for SDB in non–airway-related procedures and whether preoperative identification of high-risk children can decrease the risk of PRAEs also bear further investigation.

CONCLUSIONS

SDB is a significant cause of potential perioperative morbidity in pediatric patients undergoing surgery. A positive screen on the STBUR questionnaire is associated with an approximately 3.5-fold increased risk of PRAEs in children, independent of patient comorbidity and surgical service. Consideration should be given to implementing the STBUR questionnaire as a routine SDB screening tool in children undergoing elective surgery.

ABBREVIATIONS

CI, confidence interval
ENT, ear, nose, throat
OR, odds ratio
OSA, obstructive sleep apnea
PRAE, perioperative respiratory adverse event
SDB, sleep-disordered breathing
STBUR, Snoring, Trouble Breathing, Un-Refreshed
TA, tonsillectomy with or without adenoidectomy

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