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Association of upper respiratory tract infection with perioperative respiratory adverse events in pediatric tonsillectomy patients

A propensity-matched cohort study

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Abstract

Background Upper respiratory tract infections (URTIs) and perioperative respiratory adverse events (PRAEs) pose significant risks for anesthesia in children undergoing tonsillectomy. This study aimed to determine whether URTIs is associated with PRAEs during postanesthesia recovery after tonsillectomy.

Methods Children underwent tonsillectomy, with or without adenoidectomy at Shanghai Children's Hospital from 1 October 2022 to 30 July 2023. We assessed associations between URTIs and PRAEs during postanesthesia recovery in pediatric patients. In total, 94 patients with URTIs were propensity score-matched 1:1 with 94 patients without URTIs. The study's main outcome measure was the difference in PRAEs incidence between the two groups.

Results Children with URTIs were more likely to experience PRAEs than those without URTIs (68 of 94 [72.3%] vs. 25 of 94 [26.6%]; odds ratio [OR], 7.44; 95% CI, 3.34–17.38). They were also more likely to require interventional management post-PRAEs in the post-anesthesia care unit, such as jaw support (OR, 5.01; 95% CI, 2.06–12.20) and mask-assisted oxygenation (OR, 7.85; 95% CI, 3.98–15.50), but no other serious clinical adverse events were observed.

Conclusions Children with URTIs had an increased incidence of PRAEs, but only minor interventions were needed to relieve symptoms without serious adverse events. Most children can be safely anesthetized even with URTIs if perioperative anesthesia management is optimized.

Trial registration The study protocol was registered with the Chinese Clinical Trial Registry (registration number: ChiCTR2400084682) on 22 May 2024. https://www.chictr.org.cn/showproj.html?proj=230630.

Keywords Paediatric anaesthesia, Respiratory adverse events, Upper respiratory tract infection, Tonsillectomy, General anesthesia

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Introduction

Annually, approximately 530,000 children in the United States undergo tonsillectomy, with or without adenoidectomy [1], and the number of these surgeries in China is likely much higher. Postoperatively, the increased risk of upper airway obstruction in this population is associated with a higher likelihood of perioperative respiratory adverse events (PRAEs) [2, 3, 4]. PRAEs are the most common complications during pediatric anaesthesia, ranging from minor events (oxygen desaturation, airway obstruction, coughing, wheezing) to major events (laryngospasm, bronchospasm) [5–6]. These complications can prolong hospitalisation, increase costs, and cause physical and psychological trauma to children and parents, especially in those undergoing tonsillectomy and adenoidectomy [7–8].

Upper respiratory tract infections (URTIs) are a significant independent risk factor for PRAEs in children [9, 10, 11, 12]. Pediatric patients average 6–8 URTIs episodes per year [13]. Studies suggest that children with a current or recent URTIs experience PRAEs at a rate of 24–66%, compared to 8–47% in those without URTIs [9–10, 14–15]. Moreover, instrumental manipulation of the upper airway and invasive procedures, such as tonsillectomy and tracheal intubation, significantly increase the risk of PRAEs.

There is considerable debate, but no consensus, on the impact of elective surgery on PRAEs in children with URTIs. Although children with URTIs pose a challenge for anesthesiologists, cancellations are rarely necessary [16]. Few studies have examined the effect of different time points after URTIs on PRAEs occurrence [10, 12, 17]. However, no conclusions can be drawn regarding this population's more severe anaesthesia-related complications (laryngospasm, bronchospasm, arterial oxygen desaturation, and breath holding or apnea).

To address this gap in evidence, we conducted a retrospective, propensity score-matched analysis to examine the effect of preoperative URTIs on the incidence of PRAEs in children undergoing tonsillectomy, with or without adenoidectomy. We hypothesised that preoperative URTIs would increase the incidence of PRAEs.

Methods

Ethics

This retrospective cohort study was approved by the Research Ethics Committee of Shanghai Children's Hospital (Chairperson Prof. Lv Zhibao), affiliated with Shanghai Jiao Tong University School of Medicine, China (No. 2024R032-E01) on the 18th March 2024. The study protocol was registered with the Chinese Clinical Trial Registry (registration number: ChiCTR2400084682; https://www.chictr.org.cn/showproj.html?proj=230630; principal investigator: Yan Jiang; registration date: May 22, 2024). The study adhered to the "Ethical Principles for Medical Research Involving Human Subjects" outlined in the Declaration of Helsinki and amended by the World Medical Association. The requirement for informed consent was waived due to the study's retrospective nature. We followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement.

Study population

A prospective database of children undergoing tonsillectomy and adenoidectomy has been maintained since our facility began these procedures. All surgeries were performed by a single otorhinolaryngology team using consistent clinical protocols, care patterns, and perioperative orders. Data were gathered from anaesthetists and clinicians during patient care and verified by the principal investigator of the anesthesiology department. Data were retrospectively collected between October 2022 and July 2023.

Inclusion criteria were: (1) children with obstructive sleep apnea-hypopnea syndrome; (2) primary tonsillectomy and/or adenoidectomy; (3) ASA physical status of 1 or 2; (4) complete medical history information. Exclusion criteria were: (1) preoperative SpO2 < 95% without supplemental oxygen; (2) chronic or severe anaemia; (3) conditions like congenital heart disease, liver, or renal insufficiency; (4) postoperative fever or cough unrelated to the respiratory system (including but not limited to surgical site infection, atelectasis, transfusion reactions, drug-induced fever, malignant hyperthermia, and central causes).

Clinical management of both groups

All children were required to fast for 8 h for solids and 2 h for clear liquids before surgery. Upon arriving in the anaesthetic preparation room, children received intranasal premedication 30 to 60 min before surgery. They received intranasal midazolam (0.1 mg/kg) with 0.9% saline to achieve a final 1–2 mL volume. Midazolam took effect in 10 to 15 min and could achieve satisfactory sedation within 30 min.

The anaesthetist determined the type of anaesthesia induction (inhalational or intravenous). Preoxygenation was routinely performed. Tracheal tubes were used for airway management in all children. After surgery, oral secretions and irrigation fluid were suctioned to prevent aspiration, and children with tracheal tubes were transferred to the post-anesthesia care unit (PACU). Extubation was performed by a pediatric anesthesiologist in the PACU when the child was awake. Neostigmine was administered if residual muscle relaxation was observed. Postoperative pain was assessed using the Wong-Baker Pain Scale [18]. If the score exceeded 4, fentanyl (0.5–1.0 μg/kg) was administered for pain management.

Patients were returned to the ward when their Steward score exceeded 4. Anaesthetic management adhered to Chinese anesthesiology guidelines and expert consensus without deviation.

Outcome measure

The primary outcome was the difference in the incidence of PRAEs between the two groups in a propensity score-matched cohort of pediatric patients. PRAEs included minor adverse events (oxygen desaturation, airway obstruction, coughing, or wheezing) and major adverse events (laryngospasm and bronchospasm).

Secondary outcomes included the frequency of individual PRAEs, the incidence of PRAEs during recovery (from the end of surgery to PACU discharge), children requiring interventions (jaw support, mask-assisted oxygenation, oropharyngeal airway assistance, and mechanical ventilation), postoperative pain score, postoperative nausea and vomiting (PONV), perioperative SpO2 and heart rate values.

Propensity score matching

We conducted one-to-one propensity score matching to account for differences between cohorts with and without URTIs, defined by at least two symptoms (rhinorrhea, sore throat, sneezing, nasal congestion, malaise, cough, or fever over 38℃) [20], using absolute standardised mean differences. Matching variables included age, body mass index, sex, ASA physical status (1 or 2), passive smoking, preoperative leukocyte count, and anaesthesia type. Matching was done using nearest neighbour greedy matching with a calliper width of 0.2 times the standard deviation of the logit of the propensity score [19]. An absolute standardised mean difference < 0.2 indicated an excellent balance between propensity-matched groups.

A post-hoc power analysis was conducted using the sample size obtained after propensity score matching. With 94 children in each group (URTIs and non-URTIs), there was over 80% power to detect a 21% difference in PRAE incidence, deemed clinically significant, assuming a 26% incidence in non-URTI children as reported by Wudineh et al. [15]. Power calculations were performed using PASS software (NCSS, Kaysville, UT).

Statistical analysis

Statistical analyses were conducted using SPSS Statistics version 26.0 (IBM, Armonk, NY, USA). Categorical data are presented as patient numbers (%) and analysed using Fisher's exact test. Variables with multiple groups were analysed using the Chi-squared test. Continuous data are presented as mean (standard deviation) or median (interquartile range). The normality of continuous data was assessed using the Shapiro–Wilk test. Student's t-test was used to compare the means of variables with normal distribution. The Mann–Whitney U test was used for variables without normal distribution. Conditional logistic regression was used to compare outcomes in the matched cohort, accounting for patient clustering within centres. Results from logistic regression are expressed as odds ratios (OR) with 95% confidence intervals (CIs) and p-values.

Results

Study patients

From October 2022 to July 2023, 612 pediatric tonsillectomy and adenoidectomy cases were registered. Of these, 95 patients had URTIs symptoms, while 517 did not. After 1:1 propensity score matching, 94 children were assigned to each cohort, with and without URTIs. Before matching, the groups differed in age, sex, and anaesthesia type but were balanced on these variables post-matching (Table 1).

Primary outcome

We compared the incidence of PRAEs in the matched groups (Table 2). After adjusting for age, sex, ASA status, BMI, and passive smoking, children with URTIs were more likely to experience PRAEs than those without URTIs (68 of 94 [72.3%] vs. 25 of 94 [26.6%]; OR, 7.44; 95% CI, 3.34–17.38). Figure 1 compares the incidence of PRAEs between the two groups.

Secondary outcomes

Table 2 details the frequency of individual PRAEs between the two groups in the PACU. Children with URTIs were more likely to experience desaturation compared to those without URTIs (OR, 7.89; 95% CI, 4.09–15.23). Incidences of coughing (OR, 4.97; 95% CI, 2.66–9.32) and airway obstruction (OR, 8.06; 95% CI, 3.37–19.34) were higher in the URTI group.

Table 3 compares the proportion of patients requiring interventional management post-PRAEs in the PACU extubation phase between the two groups. Children with URTIs had higher incidences of jaw support assistance (OR, 5.01; 95% CI, 2.06–12.20) and mask-assisted oxygenation (OR, 7.85; 95% CI, 3.98–15.50) than those without URTIs.

Table 4 compares postoperative non-respiratory adverse events. Children with URTIs spent more time in the PACU post-extubation compared to those without URTIs. Extubation time, PONV, and postoperative hospital stay did not differ significantly between the groups. Wong-Baker Pain Scale scores and postoperative analgesia were similar between the groups. Figures 2 and 3 show comparisons of SPO2 and heart rate values at different times between the groups. Mean SPO2 values at 3, 6, 9, and 30 min post-extubation were significantly

Table 1 Patient characteristics before and after 1:1 propensity score matching. Values are numbers (proportion) or mean (SD)

	Before matching		SMD*	After matching		SMD*
Characteristic	**Children with URTIs (*n* = 95)**	**Children without URTIs (*n* = 517)**		**Children with URTIs (*n* = 94)**	**Children without URTIs (*n* = 94)**	
Age, years						
0–3	21 (22.1%)	101 (19.5%)	0.07	21 (22.1%)	16 (17.0%)	0.13
4–6	49 (51.6%)	287 (55.5%)	0.08	48 (51.1%)	56 (59.6%)	0.17
7–9	19 (20%)	59 (11.4%)	0.26	19 (20.2%)	18 (19.1%)	0.03
10–13	6 (6.3%)	78 (13.5%)	0.22	6 (6.4%)	4 (4.3%)	0.09
Sex, n (%)						
Male	61 (64.2%)	269 (52%)	0.24	61 (64.9%)	55 (58.5%)	0.13
Female	34 (35.8%)	248 (48%)		33 (35.1%)	39 (41.5%)	
BMI; kg m^{-2}	17.2 (3.2)	16.7 (2.8)	0.17	17.2 (3.2)	16.8 (3.0)	0.13
ASA physical status, n (%)						
I	78 (82.1%)	421 (81.4%)	0.02	78 (82.9%)	74 (78.7%)	0.11
II	17	96		16	20	
Passive smoking, n (%)	8 (8.4%)	69 (13.3%)	0.15	8 (8.5%)	11 (11.7%)	0.11
Abnormal preoperative leukocyte count[#], n (%)	8 (8.4%)	51 (9.9%)	0.05	8 (8.5%)	10 (10.6%)	0.07
Anesthesia type, n (%)						
Intravenous	18 (18.9%)	153 (29.6%)	0.24	18 (19.1%)	21 (22.3%)	0.07
Inhalation	77 (81.1%)	364 (70.4%)		76 (80.9%)	73 (77.7%)	

Before matching, the groups differed concerning age, sex, and anaesthesia type for registry entry but were balanced on these variables after matching

Abbreviations: URTI, upper respiratory tract infections; SMD, absolute standardised mean difference; BMI, Body mass index

*Absolute SMD values < 0.2 indicate a good balance between the two groups

[#] Preoperative white blood cell count higher than 13.5×10^9 L^{-1}

Table 2 Comparison of the incidence of each PRAE between the 2 groups over the perioperative period (from tracheal extubation to discharge from the post-anesthesia care unit). Values are numbers (proportion)

PRAEs	Children with URTIs (*n* = 94)	Children without URTIs (*n* = 94)	Odds ratio (95% CI)	*p*-value
Overall unadjusted	68 (72.3%)	25 (26.6%)	7.22 (3.79–13.73)	< 0.001
Overall adjusted*	68 (72.3%)	25 (26.6%)	7.44 (3.34–17.38)	< 0.001
Major				
Laryngospasm	8 (8.5%)	3 (3.2%)	2.83 (0.73–10.99)	0.21
Bronchospasm	3 (3.2%)	2 (2.1%)	1.52 (0.25–9.29)	1.00
Minor				
Desaturation	64 (68.1%)	20 (21.3%)	7.89 (4.09–15.23)	< 0.001
Coughing	58 (61.7%)	23 (24.5%)	4.97 (2.66–9.32)	< 0.001
Airway obstruction	37 (39.4%)	7 (7.4%)	8.06 (3.37–19.34)	< 0.001
Stridor	9 (9.6%)	2 (2.1%)	4.81 (1.02–23.19)	0.06

*Values were adjusted for age, sex, American Society of Anesthesiologists physical status, body mass index, abnormal preoperative leukocyte count, and passive smoking

Abbreviations: PRAE, perioperative respiratory adverse event; URTI, upper respiratory tract infections

lower in children with URTIs than those without URTI ($p < 0.01$).

Discussion

Tonsillectomy and adenoidectomy are standard surgical procedures in children. This retrospective registry analysis showed that children with preoperative URTIs had a higher risk of PRAEs and required more interventional management post-extubation in the PACU compared to those without URTIs. Most PRAEs in this study were minor, resolved with minimal intervention, and showed no difference in postoperative non-respiratory adverse events between the groups.

The incidence of PRAEs in children with preoperative URTIs was 72.3%, higher than the 6–30% reported in previous studies [17, 20, 21, 22]. Several explanations may account for this finding. Airway trauma during tonsillectomy and adenoidectomy causes the upper respiratory tract and surrounding tissues to swell, leading to secretion retention and increased PRAE risk 23]. Additionally, preoperative SARS-CoV-2 co-infection in children may elevate the risk of postoperative PRAEs [24]. Our centre discontinued mandatory preoperative

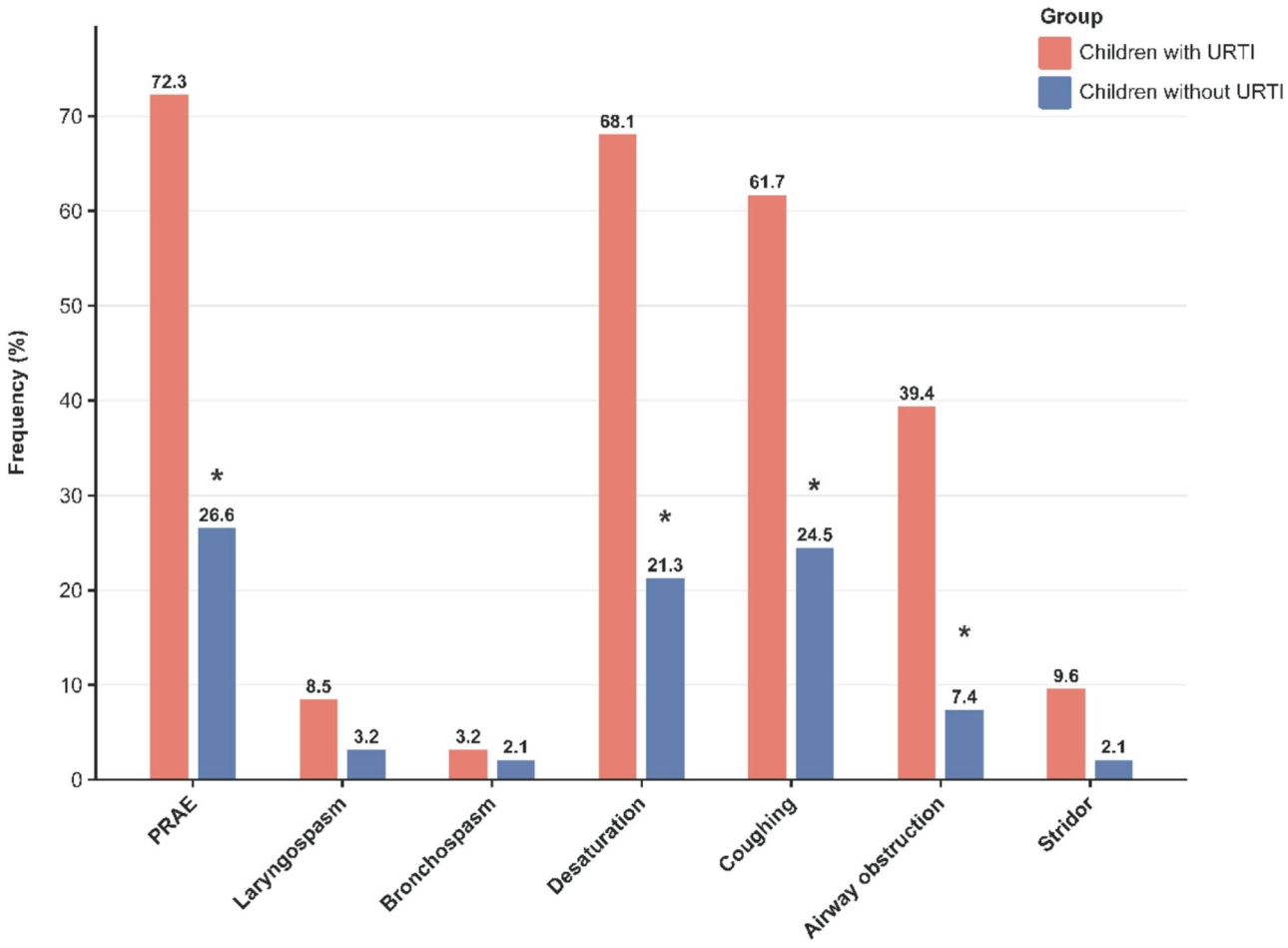

Fig. 1 Comparison of incidence of PRAEs between the two Groups. *$P < 0.001$

Table 3 Comparison of the proportion of patients requiring interventional management after PRAEs in the post-PACU extubation phase between the two groups. Values are numbers (proportion)

PRAEs	Children with URTIs ($n = 94$)	Children without URTIs ($n = 94$)	Odds ratio (95%CI)	*p*-value
Jaw support assistance	27 (28.7%)	7 (7.4%)	5.01 (2.06–12.20)	< 0.001
Mask-assisted oxygenation	58 (61.7%)	16 (17.0%)	7.85 (3.98–15.50)	< 0.001
Oropharyngeal airway assistance	6 (6.4%)	1 (1.1%)	6.34 (0.75–53.73)	0.11
Mechanical ventilation assistance	4 (4.3%)	1 (1.1%)	4.13 (0.45–37.69)	0.36

Abbreviations: PRAE, perioperative respiratory adverse event; URTI, upper respiratory tract infections

Table 4 Comparison of postoperative Non-respiratory adverse events. Values are number (proportion) or, mean (SD) or median (IQR)

Variable	Children with URTIs ($n = 94$)	Children without URTIs ($n = 94$)	Odds ratio (95%CI)	*p*-value
Extubation time, min	8.99 (1.59)	8.72 (1.75)	NA	0.24
Time spent in the post-anesthesia care unit after the extubation, min	46.28 (9.56)	35.88 (6.23)	NA	< 0.001
Length of Hospital Stay, day	2 (1–3)	2 (1–3)	NA	0.56
Wong-Baker pain score at 24 h postoperatively	2.0 (1.0–2.0)	2.0 (1.0–2.0)	NA	0.32
Children requiring analgesics, n (%)	21 (22.3%)	30 (31.9%)	0.61 (0.28–1.32)	0.10
PONV, n (%)	3 (3.2%)	5 (5.3%)	0.59 (0.10–3.51)	0.72

Abbreviations: URTIs, upper respiratory tract infections; PONV, Postoperative nausea and vomiting

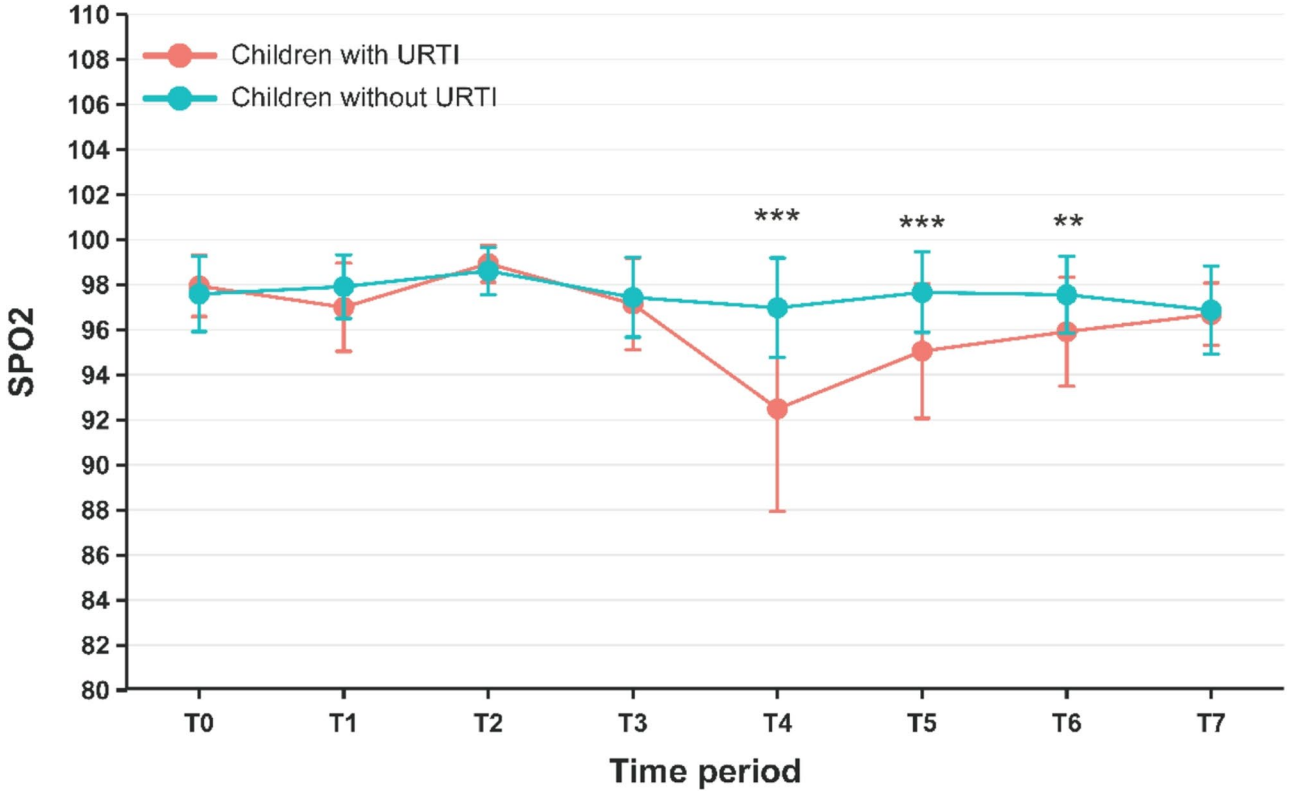

Fig. 2 SPO_2 Values at Different Times. T0, baseline; T1, after induction; T2, after successful endotracheal tube insertion; T3, after endotracheal tube removal; T4, 3 min after endotracheal tube removal; T5, 6 min after endotracheal tube removal; T6, 9 min after endotracheal tube removal; T7, 30 min after endotracheal tube removal. $^{**}P < 0.01$, $^{***}P < 0.001$

screening for SARS-CoV-2 and other respiratory viruses in the later stages of the pandemic, potentially increasing the risk of postoperative PRAEs. However, data on perioperative risks following tonsillectomy in children with SARS-CoV-2 and comorbid URTIs are limited [25, 26]. Finally, respiratory events may have been underreported in patients with planned tonsillectomy admissions, as minor events might have been anticipated by PACU staff [27].

Children with URTIs had a significantly higher incidence of PRAEs, particularly oxygen desaturation and coughing. Coughing is a physiological response to protect the airway from aspiration. Persistent coughing may lead to complications such as laryngospasm, oxygen desaturation, and airway obstruction [28]. Symptoms of children with URTIs depend on the anatomical location of the infected mucous membranes. Rhinovirus typically inoculates the nasal mucosa, causing a runny nose, and can spread to the throat and trachea, whereas influenza virus prefers the tracheobronchial epithelia [29]. Viral infection of the mucous membranes causes airway inflammation. Airway inflammation can increase secretions, airway susceptibility, and bronchial hyperreactivity, raising the risk of PRAEs [30]. Additionally, some viruses produce neuraminidase, which inhibits muscarinic type 2 receptors, increasing acetylcholine release [31]. Furthermore, viral-induced release of tachykinin and neuropeptides has been described [32]. Both pathways raise the likelihood of bronchospasm.

Although children with URTIs often require more frequent interventional management after PRAEs in the post-PACU extubation phase, this is usually limited to minor interventions such as jaw support assistance and mask-assisted oxygenation. There was no significant difference in SPO2 between the two groups 30 min after endotracheal tube removal, nor was there a difference in hospital stay length. Some suggest rescheduling surgery for children with URTIs, delaying it by 4–6 weeks after each of the 6–8 URTIs per year [9, 13, 15, 17, 20]. This severely restricts the ideal surgical timeframe and may lead to recurrent cancellations, negatively impacting the patient, their family, and the healthcare system. Even when the URTIs resolves and airway hyperreactivity decreases, the risk of PRAEs persists due to conditions like wheezing or exposure to smoking. However, some authors suggest that children with mild URTIs can be safely anesthetised, as the issues encountered are generally easily treated without long-term sequelae [22, 33, 34]. Our findings support the notion that although children with URTIs experience more frequent PRAEs in

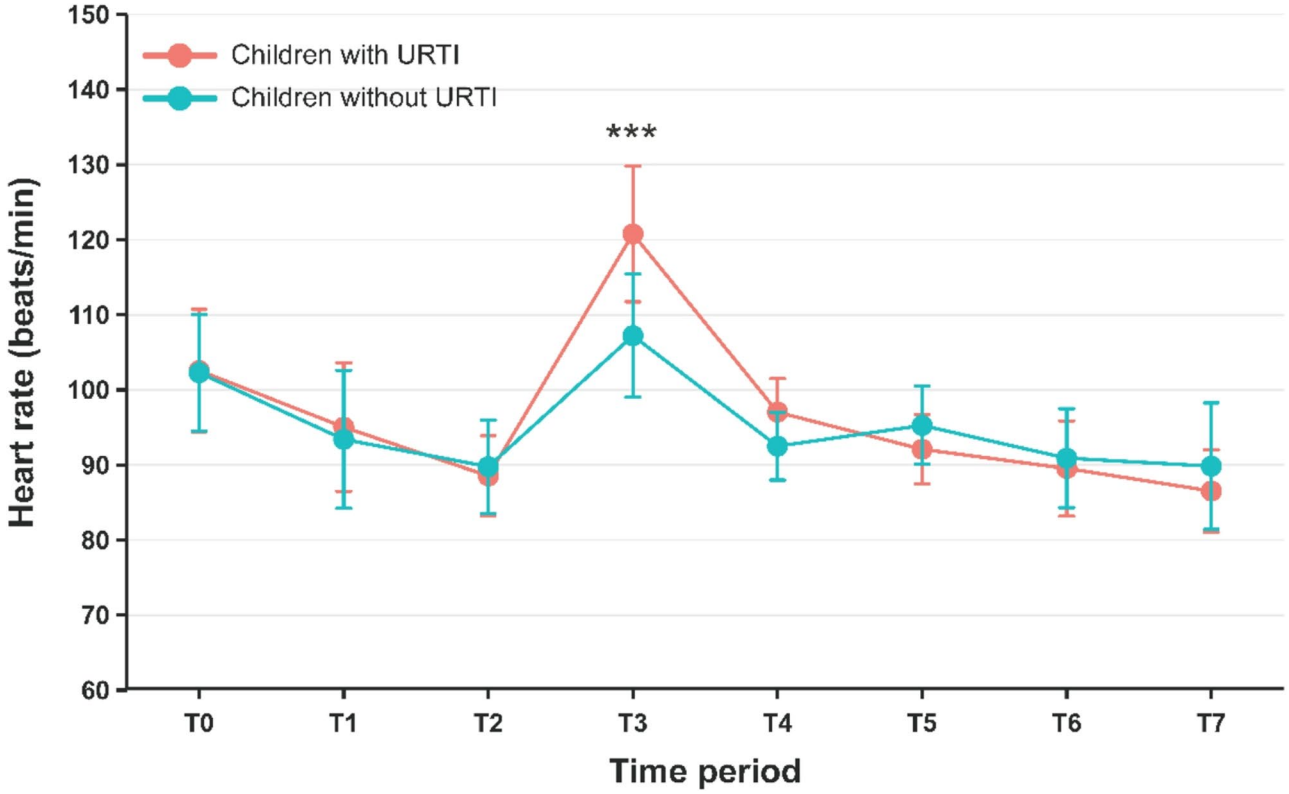

Fig. 3 Heart Rate Values at Different Times. T0, baseline; T1, after induction; T2, after successful endotracheal tube insertion; T3, after endotracheal tube removal; T4, 3 min after endotracheal tube removal; T5, 6 min after endotracheal tube removal; T6, 9 min after endotracheal tube removal; T7, 30 min after endotracheal tube removal. ***$P < 0.001$

the short term of postoperative recovery, these can be managed with minor interventions and do not prolong hospitalisation.

A balance must be found between the clinical judgment of surgical fitness and the risk of PRAEs associated with other factors. During anaesthesia and surgery, optimising perioperative management is crucial to reducing the risk of PRAEs. The decision to cancel surgery should balance the risks and benefits for each child, considering factors such as PRAEs risk, healthcare resource waste, prior surgery cancellations, wait time, travel distance, and parents' work schedules. In our study, children presenting with mild URTIs did not demonstrate a statistically significant increase in severe PRAEs relative to those without URTIs. Nevertheless, these findings should not be misconstrued to suggest negligible clinical risk. Even subtle airway inflammation in children can predispose them to bronchospasm, oxygen desaturation, or other anesthetic challenges if not recognized early. Overall, we believe careful implementation of anaesthesia is more critical than data-based risk prediction.

We recognize several inherent limitations associated with the retrospective design of our study. Firstly, although propensity score matching was utilized to achieve group comparability, residual confounding factors possibly remain unaddressed by the model. Secondly, our analysis did not evaluate potential variability in anaesthetic resuscitation quality associated with differences in anesthetists' experience during the recovery phase. Thirdly, the subjective definition of postoperative fever or non-respiratory cough relied exclusively on surgeons' clinical judgment and laboratory blood analyses for exclusion criteria, potentially excluding certain children with upper respiratory tract infections who could otherwise qualify. Consequently, this approach may have inadvertently introduced selection bias into the data. Fourthly, our investigation assessed the risk of PRAEs in children with URTIs only during the immediate postoperative interval, without conducting long-term follow-up evaluations. Importantly, respiratory pathogens can persist long after the surgical procedure has concluded. These pathogens might not be readily identifiable in the immediate postoperative phase. Fifthly, individual variability among children was apparent and might be associated with differences in parental educational attainment. Parental education levels were not assessed in this research, representing a potentially overlooked confounding variable.

Conclusion

In conclusion, the rate of PRAEs immediately after tonsillectomy and adenoidectomy was higher in children with preoperative URTIs, requiring more mild interventions. However, most children can be safely anesthetised despite URTIs if perioperative anaesthesia management is optimised.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13052-025-02013-8.

Supplementary Material 1

Supplementary Material 2

Acknowledgements
Not applicable.

Author contributions
SH Yu and Y J designed the study, collected patient data, performed data interpretation, and drafted the initial version of the paper. R W and JJ C conducted the studies and assisted in data collection. C X and J Y carried out the statistical analysis and contributed to the study's design. Additionally, Y J was involved in the acquisition, analysis, and interpretation of the data. All authors read and approved the final manuscript.

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Data availability
The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Research Ethics Committee of Shanghai Children's Hospital, affiliated with Shanghai Jiao Tong University School of Medicine, China (No. 2024R032-E01) on the 18th March 2024. The study adhered to the "Ethical Principles for Medical Research Involving Human Subjects" outlined in the Declaration of Helsinki and amended by the World Medical Association.

Consent for publication
Not applicable.

Competing interests
The authors declare that we have no competing interest.

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