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Respiratory viral panels and pediatric airway evaluation: The role of testing for upper respiratory infections to stratify perioperative risk

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ABSTRACT

Objectives: Children admitted with stridor and respiratory distress comprise a complex patient group that requires the otolaryngologist to decide when to assess and intervene with direct laryngoscopy and bronchoscopy (DLB). Historically, the diagnosis of viral upper respiratory tract infection (URTI) can lead to postponement of surgery due to concerns of perioperative complications related to acute illness. Respiratory viral panels (RVP) are often used to confirm the presence of recent or active viral infection and can affect the differential diagnosis of upper airway obstruction. This study examined whether positive RVP testing is associated with perioperative complications and operative findings in pediatric patients undergoing inpatient DLB.

Methods: A retrospective chart review of 132 pediatric patient encounters was performed. Viral testing results, DLB indication, DLB findings, and perioperative complications were compared.

Results: Sixty encounters (45.5%) involved a positive RVP, and 72 (54.5%) involved a negative RVP. Those with positive RVP were less likely to have a preoperative structural airway diagnosis ($P = .0250$) and more likely to have a history of recurrent upper respiratory infections ($P = .0464$). The most common reason for DLB was the need to assess the airway due to concern for structural pathology. Anatomic abnormalities were seen in a majority of encounters (77.3%). Laryngospasm occurred in 1 (1.7%) RVP positive and 1 (1.4%) RVP negative encounter, and 2 (2.8%) RVP negative encounters required reintubation. No other major complications were observed. No association was noted between RVP results and incidence of major or minor complication.

Conclusions: Major perioperative complications after surgical intervention with DLB for the management of complex, inpatient children with stridor and respiratory distress are rare. RVP positivity, specific pathogens identified on RVP, and presence of URI symptoms were not associated with perioperative complications.

1. Introduction

Inpatient evaluation of children with stridor often involves surgical intervention with direct laryngoscopy and bronchoscopy (DLB) to assess for the presence of subglottic and lower airway pathology. In addition to stridor, obstruction may manifest as difficulty to extubate or acute respiratory distress. These signs are often due to fixed airway lesions, inflammatory or infectious processes or a combination of both. Because patients can have a complex presentation, acute decompensation or increased work of breathing can be suggestive of not only

laryngotracheal pathology but also underlying upper respiratory tract infection (URTI). The presence of a URTI has been shown to increase perioperative morbidity and may in turn increase the risk of DLB [1,2]. As pediatric otolaryngologists, we are faced with the decision to proceed with surgical intervention or postpone until the resolution of URTI symptoms. However, the safety of DLB in acutely ill pediatric patients is not well described.

Respiratory virus testing is available to objectively assess for URTI in children [3]. Respiratory viral panels (RVP) are easily administered by nasopharyngeal swabs and are most commonly used to differentiate

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between viral and bacterial infections, thus impacting clinical decision making. In the inpatient setting, positive viral testing may steer management by influencing the timing of anesthesia clearance and surgical intervention. In this study, a cohort of pediatric patients undergoing inpatient assessment for acute respiratory symptoms with recent history of RVP testing were examined retrospectively with the hypothesis that a positive RVP does not increase perioperative complications in children undergoing DLB.

2. Methods

A retrospective cohort study was conducted at a single pediatric tertiary hospital system to evaluate outcomes of patients who underwent a surgical airway procedure and had been assessed with RVP. Inclusion criteria consisted of patients aged 0 to 18 at the time of admission between January 2014 and December 2018 having undergone laryngoscopy or bronchoscopy (current procedural terminology (CPT) 31526 and 31622) and having received an RVP within 6 weeks prior to surgery. The study was approved by the Nationwide Children's Hospital Institutional Review Board.

Patients were excluded if they had one or more of the following: hospital admission within 10 days of birth, lack of bronchoscopy under anesthesia, non-otolaryngology surgery performed in the same case (combination cases with other services), tracheostomy performed in the same case, tracheostomy dependence, and extensive, non-airway, otolaryngology procedures performed in the same case. These exclusion criteria were necessary in order to eliminate complications related to other comorbid conditions or procedures. Medical records for all remaining patients were reviewed for perioperative events and operative details including surgical indications and intraoperative findings.

Demographic information, comorbidities, dates and results of RVP tests, dates of DLB, and viral prodrome symptoms were extracted from medical records. Indications for DLB were identified within the surgical note and classified as structural concern, clinical concern, infection, bleeding, and suspected foreign body/aspiration. Structural concerns included patients presenting with stridor and dysphonia, as well as patients diagnosed with stenosis, malacia, vocal cord paralysis, and obstruction on preoperative flexible laryngoscopy. Clinical concern represented patients who had respiratory distress or respiratory insufficiency with subsequent DLB based on the surgeon's judgment.

Patients were treated by a group of ten pediatric otolaryngologists. Perioperative management was performed according to standard of care. While there was potential for some variation in technique from case to case, standard DLB for the group included the use of topical lidocaine, exposure with a Parsons laryngoscope and visualization of the larynx and trachea with rod lens telescope and ventilating bronchoscope. Airway pathologies identified on DLB were characterized by type and location: supraglottis, glottis, subglottis, trachea, and bronchi. Additional endoscopic surgical interventions performed alongside of DLB were recorded. Symptom-based URTI infection diagnosis was made when a patient exhibited a minimum of 2 URTI symptoms (rhinorrhea, sore throat, sneezing, nasal congestion, malaise, cough, or fever greater than 38 °C) [4].

The exposure of interest was a positive RVP test within 6 weeks prior to the DLB [1,5,6]. Specific pathogens were recorded for patients who were viral positive on RVP test. A Film Array Respiratory Viral Panel PCR (FARVPP) (BioFire, Salt Lake City, UT, USA), which is a real-time PCR test was used to detect the following pathogens: Adenovirus, Coronavirus, Human Metapneumovirus, Human Rhino/Enterovirus, Influenza A, Influenza B, Parainfluenza Virus 1–4, Respiratory Syncytial Virus, *Bordetella pertussis*, *Chlamydomphila pneumoniae*, and *Mycoplasma pneumoniae*. The FARVPP test has 97.1% sensitivity and 99.3% specificity [7]. Respiratory samples were retrieved from the nasopharynx, nares, trachea, or bronchoalveolar lavage.

Major perioperative airway complications (intraoperative and immediate postoperative) were examined and consisted of laryngospasm,

bronchospasm, reintubation postoperatively, emergent tracheostomy, cardiac arrest, and death. Laryngospasm, bronchospasm, and reintubation were identified using reported events in the anesthesia record. Minor airway complications were examined and defined as oxygen desaturation and changes in the required respiratory support over the perioperative period. Oxygen desaturation was defined as peripheral capillary oxygen saturation (SpO₂) less than 90% at any time during the case. Baseline respiratory support requirements (nasal cannula, CPAP, ventilator, etc.) at the beginning of the perioperative period were reviewed, and compared to the requirements both in the PACU setting and the inpatient service to ascertain whether the patient had an increase, decrease, or no change in requirement after the surgical procedure.

Statistical analyses were conducted with unique encounters rather than unique patients, as there were four patients each with two eligible encounters. RVP closest to surgical intervention were used in encounters with more than one RVP in the six-week time period. Categorical patient characteristics were reported as frequencies and proportions while continuous variables were reported as medians and interquartile ranges. Chi square and Fisher's exact tests were used to test for association between categorical variables and Wilcoxon two sample tests were used for continuous variables. Tests for association were carried out comparing RVP results (positive or negative) with patient characteristics, airway pathologies, perioperative major and minor complications, and viral prodrome. Tests for association were also carried out looking at the association of perioperative major and minor complications to individual virus type and viral prodrome. The relationship between RVP and perioperative complications was evaluated for the entire cohort as well as subgroups of the population based on the number of weeks prior to DLB that an RVP was performed. Findings were determined to be significant at $P < .05$. All statistical tests were conducted on SAS Enterprise version 7.15.

3. Results

A total of 132 encounters were observed in this cohort. There were 72 RVP-negative (54.5%) and 60 RVP-positive (45.5%) encounters. Median patient age at intervention was 0.7 years (IQR: 0.2–2.8). Median hospital length of stay was 11 days (IQR: 5.0–33.5). Baseline characteristics and association with RVP results are listed in Table 1. Patients with positive RVP were less likely to have a preoperative structural airway diagnosis ($P = .0250$) and more likely to have history of recurrent upper respiratory infections ($P = .0464$). No other association between patient characteristics and RVP results were noted. No differences in RVP results were found despite seventy-four percent of all encounters having been characterized as ASA class III or IV indicative of a high-risk population ($P = .0559$) The most common reason for DLB was to assess for structural airway abnormality, followed by airway assessment due to clinical concern (Table 2). The most common viral pathogens discovered in RVP positive encounters were Rhinovirus/Enterovirus (29, 22.0%), Respiratory Syncytial Virus (7, 5.3%), and Human Metapneumovirus (5, 3.8%) (Table 3).

Airway pathology on DLB was diagnosed in 77.3% of encounters with no difference between RVP negative encounters ($n = 59, 81.9\%$) compared to RVP positive encounters ($n = 43, 71.7\%$) (Table 2). Anatomic abnormalities were most often found in the subglottis among RVP positive encounters ($n = 23, 38.3\%$) and the supraglottis among RVP negative encounters ($n = 26, 36.1\%$). Fifteen percent of encounters had abnormalities at multiple levels of the airway. Nearly one third of encounters (25% RVP positive and 31.9% RVP negative) required an endoscopic intervention to address the airway pathology seen on DLB. These interventions included supraglottoplasty, foreign body removal, injection laryngoplasty, and excision of a mass, cyst, or granulation tissue.

Four (3.0%) encounters had major airway complications reported by anesthesia (Table 4). Major complications included laryngospasm (n

Table 1
Patient characteristics ([†]Fisher's Exact Test; [‡]Wilcoxon Two Sample Test).

Variable	Patient Characteristic	Overall Characteristics	RVP Positive	FARVPP Negative	P value
		N (%) or median (IQR)	N (%) or median (IQR)	N (%) or median (IQR)	
All patients		132 (100)	60 (100.0)	72 (100)	
RVP Results	Negative	72 (54.5)			
	Positive	60 (45.5)			
Age, y		0.71 (0.18, 2.8)	1.0 (0.2, 2.6)	0.5 (0.2, 3.0)	‡0.4058
Female		57 (43.2)	25 (41.7)	32 (44.4)	0.7483
Race	White	88 (67.7)	40 (69.0)	48 (66.7)	0.1409
	Black	23 (17.7)	13 (22.4)	10 (13.9)	
	Other	19 (14.6)	5 (8.6)	14 (19.4)	
Ethnicity	Not Hispanic or Latino	125 (94.7)	58 (96.7)	67 (93.1)	0.1407
	Hispanic or Latino	4 (3.0)	0 (0.0)	4 (5.6)	
	Unknown	3 (2.3)	2 (3.3)	1 (1.4)	
Length of Stay		11 (5.0, 33.5)	9 (3.5, 25.0)	12 (6.0, 42.0)	‡0.0566
BMI		16.5 (14.8, 18.9)	16.8 (15.3, 18.6)	16.3 (14.4, 19.2)	‡0.9921
ASA	Class I	4 (3.1)	3 (5.1)	1 (1.4)	0.0559
	Class II	30 (22.9)	18 (30.5)	12 (16.7)	
	Class III	67 (51.2)	23 (39.0)	44 (61.1)	
	Class IV	30 (22.9)	15 (25.4)	15 (20.8)	
	None	20 (15.2)	12 (20.0)	8 (11.1)	
Comorbidities	Preoperative Structural Airway Diagnosis	58 (43.9)	20 (33.3)	38 (52.8)	0.1561
	Prematurity	35 (26.5)	18 (30.0)	17 (23.6)	0.4077
	Cardiovascular Disease History	32 (24.2)	10 (16.7)	22 (30.6)	0.0637
	Poor Feeding/Failure to Thrive	30 (22.7)	12 (20.0)	18 (25.0)	0.4949
	Neurologic Disease History	23 (17.4)	9 (15.0)	14 (19.4)	0.5027
	Lung Disease History	22 (16.7)	7 (11.7)	15 (20.8)	0.1594
	Gastroesophageal Reflux Disease	21 (15.9)	12 (20.0)	9 (12.5)	0.2408
	Prior DLB	20 (15.2)	8 (13.3)	12 (16.7)	0.5948
	Asthma	13 (9.9)	7 (11.7)	6 (8.3)	0.5222
	Congenital/Other Chromosomal Disease	13 (9.9)	6 (10.0)	7 (9.7)	0.9575
	Down Syndrome	8 (6.1)	2 (3.3)	6 (8.3)	†0.2907
	Recurrent URTIs	7 (5.3)	6 (10.0)	1 (1.4)	†0.0464
	Obstructive Sleep Apnea	4 (3.0)	1 (1.7)	3 (4.2)	†0.6256

= 1, 1.7% RVP positive, n = 1, 1.4% RVP negative) and need for re-intubation (n = 2, 2.8% RVP negative). There were no bronchospasms, emergent tracheostomies, cardiac arrests, or mortalities. These major airway complications all occurred in patients who were younger than one year of age. No association was noted between prevalence of major complication and RVP results (P = .6256). Oxygen desaturation below 90% was the most common complication (n = 63, 47.7%), but an association between prevalence of oxygen desaturation and RVP result

was not observed (P = .3562. Thirty-six (27.3%) encounters required an increase in respiratory management postoperatively. No significant association was observed, however, between escalated respiratory support and RVP results (P = .8028). Additionally, no association was found between multiple viruses and surgical complications indicating presence of virus (single or multiple) was not attributed to minor or major complications. (Table 3).

Overall, RVP testing was most often performed within 1 week of

Table 2
Operative characteristics and findings ([†]Fisher's Exact Test).

Variable	Patient Characteristics	Overall Characteristics (n = 132)	RVP Positive (n = 60)	RVP Negative (n = 72)	P value
DLB Indication	Structural Concern	59 (44.7)	24 (40.0)	35 (48.6)	0.3218
	Distress/Clinical Concern	52 (39.4)	21 (35.0)	31 (43.1)	0.3456
	Foreign Body Aspiration	17 (12.9)	10 (16.7)	7 (9.7)	0.2356
	URI Infection	13 (9.9)	11 (18.3)	2 (2.8)	0.0028
	Other	9 (6.8)	5 (8.3)	4 (5.6)	†0.7311
	Bleeding	6 (4.6)	1 (1.7)	5 (6.9)	†0.2198
Airway Pathology on DLB	Yes	102 (77.3)	43 (71.7)	59 (81.9)	0.1606
DLB Finding Airway Region	Normal	30 (22.7)	17 (28.3)	13 (18.1)	0.1606
	Subglottis	40 (30.3)	23 (38.3)	17 (23.6)	0.0669
	Supraglottis	37 (28.0)	11 (18.3)	26 (36.1)	0.0236
	Trachea	23 (17.4)	10 (16.7)	13 (18.1)	0.8341
	Glottis	19 (14.4)	9 (15.0)	10 (13.9)	0.8563
	Bronchi	13 (9.9)	5 (8.3)	8 (11.1)	0.5938
	None	30 (22.7)	17 (28.3)	13 (18.1)	0.2745
Number of Airway Pathology Regions	One	82 (62.1)	33 (55.0)	49 (68.1)	
	Multilevel	20 (15.2)	10 (16.7)	10 (13.9)	
	None	93 (70.5)	44 (73.3)	49 (68.1)	0.5081
	Supraglottoplasty	18 (13.6)	6 (10.0)	12 (16.7)	0.2664
	Mass/cyst excision	8 (6.1)	3 (5.0)	5 (7.1)	†0.7261
Airway Endoscopic Intervention	Foreign body removal	7 (5.3)	6 (10.0)	1 (1.4)	†0.0464
	Injection laryngoplasty	3 (2.3)	0 (0.0)	3 (4.2)	†0.2505
	Granulation tissue excision	2 (1.5)	0 (0.0)	2 (2.8)	†0.4997

Table 3
Association of virus type and risk of complications.

Virus	Count (n = 132)	Any Complication (n = 81)	Minor Complication		P value	Major Complication		
			Yes (n = 81)	No (n = 51)		Yes (n = 4)	No (n = 128)	P value
No Virus	72 (54.6)	46 (56.8)	46 (56.8)	26 (51.0)	0.5139	3 (75.0)	69 (53.9)	0.6256
Rhino/Enterovirus	29 (22.0)	15 (18.5)	15 (18.5)	14 (27.5)	0.2275	1 (25.0)	28 (21.9)	1.0000
RSV	7 (5.3)	6 (7.4)	6 (7.4)	1 (2.0)	0.2479	0 (0.0)	7 (5.5)	1.0000
Human Metapneumovirus	5 (3.8)	4 (4.9)	4 (4.9)	1 (2.0)	0.6483	0 (0.0)	5 (3.9)	1.0000
Adenovirus	4 (3.0)	2 (2.5)	2 (2.5)	2 (3.9)	0.6399	0 (0.0)	4 (3.1)	1.0000
Parainfluenza 2	3 (2.3)	1 (1.2)	1 (1.2)	2 (3.9)	0.5590	0 (0.0)	3 (2.3)	1.0000
Parainfluenza 1	2 (1.5)	1 (1.2)	1 (1.2)	1 (2.0)	1.0000	0 (0.0)	2 (1.6)	1.0000
Rhino/Enterovirus and Coronavirus	2 (1.5)	1 (1.2)	1 (1.2)	1 (2.0)	1.0000	0 (0.0)	2 (1.6)	1.0000
Rhino/Enterovirus and RSV	1 (0.8)	0 (0.0)	0 (0.0)	1 (2.0)	0.3864	0 (0.0)	1 (0.8)	1.0000
Parainfluenza 3	1 (0.8)	1 (1.2)	1 (1.2)	0 (0.0)	1.0000	0 (0.0)	1 (0.8)	1.0000
Parainfluenza 1 and RSV	1 (0.8)	1 (1.2)	1 (1.2)	0 (0.0)	1.0000	0 (0.0)	1 (0.8)	1.0000
Influenza A	1 (0.8)	1 (1.2)	1 (1.2)	0 (0.0)	1.0000	0 (0.0)	1 (0.8)	1.0000
Rhinovirus	1 (0.8)	1 (1.2)	1 (1.2)	0 (0.0)	1.0000	0 (0.0)	1 (0.8)	1.0000
Rhino/Enterovirus and Adenovirus	1 (0.8)	1 (1.2)	1 (1.2)	0 (0.0)	1.0000	0 (0.0)	1 (0.8)	1.0000
Rhino/Enterovirus and Parainfluenza 1	1 (0.8)	0 (0.0)	0 (0.0)	1 (2.0)	0.3864	0 (0.0)	1 (0.8)	1.0000
Rhino/Enterovirus and Parainfluenza 2	1 (0.8)	0 (0.0)	0 (0.0)	1 (2.0)	0.3864	0 (0.0)	1 (0.8)	1.0000
Multiple Pathogens	7 (5.3)	3 (3.7)	3 (3.7)	4 (7.8)	0.4288	0 (0.0)	7 (5.5)	1.0000

operative intervention (RVP positive (n = 39, 44.3%) and negative (n = 49, 55.7%)) (Fig. 1). Although neither major nor minor complications were found to be associated with RVP result (table 4), proportion of observable complications among RVP positive encounters were shown to increase as time interval between date of bronchoscopy and date of RVP decreased, maximizing at 1 week between the two events and non-existent by 5 weeks. Rate of complication observed for RVP positive (69%) was not different from that observed for RVP negative (65%) within one week of DLB.

To address potential effect modification of RVP by virus stage (active URI symptoms vs. asymptomatic viral shedding), we performed an analysis comparing perioperative complications using symptom-based URTI diagnosis compared to RVP-based URTI diagnosis. Among the 27 (20.5%) encounters that exhibited criteria for symptom-based diagnoses, 15 (25.0%) were RVP positive compared to 12 (16.7%) that were RVP negative (Table 5). No association was observed between symptom-based and RVP-based URTI diagnosis, nor was an association seen between symptom-based URTI diagnosis and major or minor complications.

4. Discussion

Pediatric otolaryngologists are often consulted to evaluate hospitalized children with acute airway symptoms. Presentations can vary, ranging from failure to extubate to stridor and respiratory distress. Acute processes can arise from infectious processes and can mimic static airway lesions. In clinically complex scenarios, our institution uses rapid viral testing to help establish the clinical picture and determine

the urgency of intervention as acute viral respiratory infection can increase perioperative risk of laryngospasm, bronchospasm, reintubation. Thus, a positive test may lead to medical management with steroids and close observation whereas a negative test may result in earlier operative intervention. We sought to explore these practices by examining the perioperative outcomes of patients undergoing DLB with a recent history of viral testing. Interestingly, our study showed no association between respiratory viral positivity and increased complications among children undergoing inpatient DLB. Overall rates of complications were low in spite of nearly 74% of procedures performed on ASA fitness class III/IV patients. Patient encounters that had a positive RVP test were less likely to have an initial preoperative diagnosis attributed to structural disease and were more likely to have a history of recurrent URTIs. Nearly one-half of all encounters underwent intervention due to concern for structural airway abnormality. During DLB, airway pathology was seen in over three-quarters of patient encounters, with no difference between RVP positive encounter and RVP negative encounters. Despite viral panel result, concurrent endoscopic intervention was common, performed in nearly 30% of patients overall. We identified that while minor complications are common (oxygen desaturation occurred in almost half of all patients), they responded to minimal intervention (oxygen supplementation). The only major complication observed were laryngospasm and the need for reintubation. No other major complications were noted in this study.

Our findings in the context of viral testing results are supported by previous research by Tait and Knight which showed no increase of complications in children with URTIs at the time of surgery (based on symptoms) compared to control patients [8]. A subsequent prospective

Table 4
Perioperative DLB complications (Fisher's Exact Test).

Characteristic	Overall Characteristics (n = 132)	RVP Positive (n = 60)	RVP Negative (n = 72)	P value
No complications	51 (38.6)	25 (41.7)	26 (36.1)	0.5139
Any complication	81 (61.4)	35 (58.3)	46 (63.9)	0.5139
Major	4 (3.0)	1 (1.7)	3 (4.2)	0.6256
Laryngospasm	2 (1.5)	1 (1.7)	1 (1.4)	1.0000
Reintubation	2 (1.5)	0 (0.0)	2 (2.8)	0.5003
Bronchospasm	0 (0.0)	0 (0.0)	0 (0.0)	.
Emergent Tracheostomy	0 (0.0)	0 (0.0)	0 (0.0)	.
Cardiac Arrest	0 (0.0)	0 (0.0)	0 (0.0)	.
Mortality	0 (0.0)	0 (0.0)	0 (0.0)	.
Minor	81 (61.4)	35 (58.3)	46 (63.9)	0.5139
Oxygen Desaturation (< 90%)	63 (47.7)	26 (43.3)	37 (51.4)	0.3562
Escalated Respiratory Support	36 (27.3)	17 (28.3)	19 (26.4)	0.8028

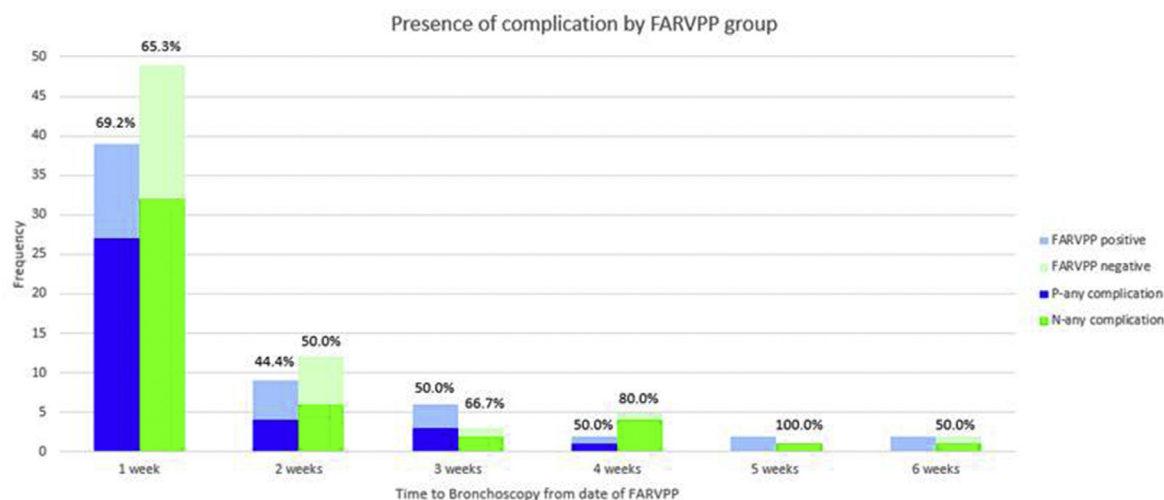


Fig. 1. Bar graph showing frequency of each RVP group across different week intervals. Percentages represent the proportion of complications and bars without proportions indicate no complications.

study showed no differences in perioperative laryngospasm, bronchospasm, or apnea between groups without URTI, with recent URTI, and with active URTI [9].

In contrast, associations have been found between URTIs and bronchospasm, laryngospasm, and oxygen desaturation in a variety of other studies [1,2,10]. Cohen and Cameron found that patients with URTI were more likely to experience respiratory-related complications [1]. However, timing of infection in relation to surgery was not established and the study relied on symptoms for URTI diagnosis. Further, Tait et al. studied adverse respiratory event incidence and risk factors for patients undergoing elective surgery who were asymptomatic, had active URTI, or had recent (past 4 weeks) URTI [4]. They determined that there was no difference in incidence of laryngospasm and bronchospasm, but active and recent URTI patients had more overall events, as well as more breath-holding spells, oxygen desaturations ($SpO_2 < 90\%$), and severe coughing events compared to children without URTI. Still another study found that patients with a history of URTI in the previous two weeks had a 3.5-fold increase in prevalence of respiratory complications [8].

The heterogeneity in findings within the literature may be attributable to different methods used to establish URTI diagnosis. Diagnosis is often defined by the presence of symptoms reported by the parent/guardian of the patients or within the patient's medical record [11]. Studies have found an increased risk of complications by using symptom history 30 days prior to surgery and also by evaluating symptoms 2 weeks prior to surgery [12]. This study, with data on both symptoms and objective RVP assessments, as well as an analysis of the time interval between viral infection and bronchoscopy was designed to address these limitations. We found that symptom-based URTI criteria were met in 20.5% of encounters compared to a URTI diagnosis rate of 45.5% when RVP was used. Interestingly, 25.0% of RVP positive encounters were deemed URTIs based on symptoms alone and 16.7% of RVP negative encounters met symptom criteria for URTI. As a result, symptom-based URTI definitions do not appear to be a reliable measure for estimating RVP findings. The relatively low rate of symptom-based diagnosis compared to RVP-based diagnosis could be due to the RVP's ability to identify the DNA of a viral pathogen that is present but not causing clinically concerning symptoms. The low correlation between the two tests might be a result of the symptoms being caused by a disease process other than upper respiratory tract infection in the hospitalized patients. Furthermore, the symptom-based diagnosis results could be confounded by comorbid conditions and are limited by what was documented in the electronic medical record. In another study, Parnis et al. found that just 4.8% of patients that reported

symptoms had a virus isolated on an immunofluorescence assay. Neither the patients who had URTI in the preceding 6 weeks nor the patients who tested positive for a viral pathogen had an increased probability of anesthetic complications [6].

DLBs are commonly performed at our tertiary pediatric hospital, which may have contributed to the low complication rate. Airway instrumentation such as foreign body removal induces mucosal trauma, which may lead to postoperative complications. Two-thirds of patients did not require airway instrumentation beyond diagnostic DLB, which may have contributed to overall low major complication rate. The treatment planning required for those patients who were found to have airway pathology may have contributed to the 11-day median length of stay seen in this cohort.

This study has several limitations. First, the retrospective nature of this study limits the characterization of perioperative outcomes to what is available in the medical record. In this study, patients were excluded if they did not have an RVP recorded within 6 weeks of DLB, were readmitted close to birth, required a tracheostomy, or had multiple surgical interventions beyond the airway. This was to create a sample that better represented those undifferentiated patients who present to the hospital with respiratory distress and do not have extremely complex healthcare needs that could contribute to adverse surgical outcomes. In doing so, our limited sample size may not have sufficient power to show any associations between RVP positivity and surgical complications should they exist. The outcomes of this study were not intended to apply to medically complex children or patients with a history of well-documented airway abnormalities. However, DLBs were performed in select patients for whom RVP was positive when medically indicated, specifically for those patients whose overall status warranted a surgical procedure despite a known URTI. Surgeons often elect to proceed to the operating room in order to visualize the patient's airway and determine the etiology of obstruction. In this way, this study population does not represent patients presenting for elective surgery for whom surgery is delayed due to suspected URTI. Additionally, only patients who had an RVP taken were compared. The decision to order RVP testing is typically made by emergency department personnel or primary treatment team. These patients received this test because there was a concern for infection causing acute respiratory distress, although RVP is not typically ordered for straightforward URTI. RVP is deferred in patients with high suspicion for structural abnormalities or history of airway pathology and low concern for viral illness. Patients with positive RVPs are spared of inappropriate antibiotics and receive proper transmission-based precautions to prevent spread of infections [13,14]. If the RVP is negative, the provider must consider alternative etiologies

Table 5
Comparison of symptom-based URTI diagnosis and RVP-based URTI diagnosis.

Viral Prodrome	Count (n = 132)	RVP Positive (n = 60)			RVP Negative (n = 72)			P-Value	Minor Complication			Major Complication				
		RVP Positive (n = 60)	RVP Positive (n = 60)	RVP Positive (n = 60)	RVP Negative (n = 72)	RVP Negative (n = 72)	RVP Negative (n = 72)		Yes (n = 81)	No (n = 51)	P value	Yes (n = 4)	No (n = 128)	P value		
Number of Viral Symptoms							0.2373									
Zero to one viral symptom	105 (79.6)	45 (75.0)	15 (25.0)	60 (83.3)	12 (16.7)	64 (79.0)	17 (21.0)	41 (80.4)	10 (19.6)	0.8482	2 (50.0)	2 (50.0)	103 (80.5)	25 (19.5)	0.1368	
Two or more viral symptoms	27 (20.5)	15 (55.6)	12 (44.4)	12 (44.4)	15 (55.6)	17 (63.0)	10 (37.0)	10 (37.0)	17 (63.0)		2 (74.1)	1 (28.6)	25 (92.6)	3 (11.4)		

leading to respiratory distress. It is possible that patients in both groups had a bacterial or viral pathogen not tested for on the RVP. It is also expected that there were patients who received DLB but were not able to be included because the RVP test was not administered.

5. Conclusion

We demonstrate that major perioperative complications are infrequent following inpatient airway management of children with stridor and respiratory distress. Results of respiratory viral panels do not influence perioperative complications. Surgical intervention with direct laryngoscopy and bronchoscopy identifies airway pathology in a large proportion of patients and often requires intervention.

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Declaration of competing interest

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