

Risk Factors for Procedural Complications of Pediatric Flexible Bronchoscopy: Experience From a Tertiary Care Centre in Northern India

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ABSTRACT

We analyzed the records of 869 children who underwent flexible bronchoscopy. We found procedural complications in 6.7% ($n = 59$), with severe events in 3.2% ($n = 28$). Age < 1 y, recurrent respiratory papillomatosis, and finding lower airway malacia on bronchoscopy were identified as independent risk factors for developing complications with adjusted odds ratio (95% CI) of [2.6 (1.3, 4.9); $P = 0.004$], [5.4 (1.7, 17.6); $P = 0.005$] and [2.1 (1.1, 4.0); $P = 0.031$], respectively.

Keywords: Airway malacia, Children, Desaturation, Recurrent respiratory papillomatosis

Complications may be encountered during flexible bronchoscopy, an essential diagnostic tool in children with respiratory problems [1]. The complication rate may be influenced by several factors including availability of resources. Limited studies are available which assess the risk factors for developing complications from resource limited centres [2]. Hence, we conducted this study to estimate the frequency of complications during flexible bronchoscopy in children and to identify the risk factors for the same.

We reviewed the records of children who underwent flexible bronchoscopy between May 2018 and Aug 2022 at the Pediatric Pulmonology Division at All India Institute of Medical Sciences, Delhi. We excluded records of children who were receiving high-flow oxygen, non-invasive/mechanical ventilation prior to procedure. We provided conscious sedation during the procedure using midazolam + fentanyl or midazolam alone (from Jan 2022 in infants). Propofol was only used in older children (> 5 y) on a case-to-case basis. Sedation was administered by a resident pursuing fellowship training in pediatric pulmonology and intensive care had received certification in advanced life support and airway management. Indications for bronchoscopy are summarized in **Table I**. 50, 29 and 16 children, respectively, had underlying congenital cardiovascular disease, chronic suppurative lung disease and malignancy as underlying condition.

Data on complications were retrieved and potential risk factors were identified. Mild complications included self-limiting mild nasal bleeds, desaturation ($\text{SpO}_2 \geq 80\% < 90\%$), and transient laryngospasm. Desaturation ($\text{SpO}_2 < 80\%$) irrespective of duration, endobronchial bleeds, bradycardia, apnea requiring positive pressure ventilation, respiratory depression, and cardiopulmonary arrest were labelled as severe complications. Procedures were performed by experienced pediatric pulmonologists/trainees under supervision in a dedicated suite. For children with mild desaturation, the procedure was continued by temporarily increasing the oxygen flow rate. In children who had severe cardiorespiratory complications, the procedure was aborted, and appropriate resuscitative measures were undertaken. We reported descriptive statistics using Stata14 (College Station, TX). We compared various parameters in children with or without complications using bivariate and multivariate logistic regression. Factors with $P < 0.1$ on bivariate analysis were subjected to multivariate logistic regression to identify independent risk factors. $P < 0.05$ was considered significant.

The study included 869 bronchoscopies in children below 18y [$< 1y$: 316 (36%), 1-5y: 301 (34.5%), $> 5y$: 252 (29%)] with a median (IQR) age of 24 (7, 96) months. A total of 59 (6.7%) children developed complications during bronchoscopy. Minor complications were present in 41 children (4.7%); mild desaturation in 29 children (3.3%). Severe complications occurred in 28 (3.2%) children and included bradycardia ($n = 6$), apnea requiring positive pressure ventilation ($n = 4$), respiratory depression ($n = 5$), respiratory distress ($n = 3$), severe desaturation ($n = 6$), and endobronchial bleeds ($n = 4$). Ten children had both minor and major complications. Among children who had apnea, one child required mechanical ventilation, and the rest recovered with bag and mask ventilation. In 24 out of 28 children with severe complications, the procedure had to be aborted, and in 4 children with endobronchial bleeds, local tranexamic acid successfully stopped the bleeding, allowing us to complete the procedure. Children, who had severe complications, were admitted to the pediatric intensive care unit or the high-dependency unit for further monitoring. The child who required mechanical ventilation was extubated after 6 hours and shifted to the ward after 24 hours. Rest of the children with severe complications recovered within the next 24 hours with tapering of respiratory support, and all were discharged after 48 hours. On bivariate analysis, age $< 1y$, heart disease, suspected airway malformations, recurrent respiratory papillomatosis, upper airway malacia and lower airway malacia were identified as significant risk factors for any complication (**Table II**). Age $< 1y$, recurrent respiratory papillomatosis, and finding lower airway malacia on bronchoscopy were found to be independent risk factors for any complications using multivariable logistic regression analysis with adjusted odds ratio (95% CI) of [2.6 (1.3, 4.9); $P = 0.004$], [5.4 (1.7, 17.6); $P = 0.005$] and [2.1 (1.1, 4.0); $P = 0.031$], respectively. There was no significant difference in the complication rate (11.5% vs 9.52%, $P = 0.780$) in midazolam plus fentanyl vs midazolam alone in infants. In our unit, there was a change of practice in providing oxygen support from masks/prongs to using a nasopharyngeal catheter (after Nov 2020) for oxygenation by the Soong technique [3]. But there was no difference in complication rate (6.2% vs 7.6%, $P = 0.443$) between both periods.

The complication rates during flexible bronchoscopy in children vary from as low as 4.5% to as high as 33.3% [2,4,5,], prompting reflection on the procedural nuances and patient cohorts. The variation may be due to different sedation practices, with some employing general anesthesia [2,6] and others, like ours, using conscious sedation [4]. Complication rates using general anesthesia as reported by Carlens et al [2] of 7.2% overall with 3.9% serious complications, are similar to those observed in our study, suggesting no clear superiority of one approach over the other. Moreover, the study by Carlens et al [2] is from developed country compared to ours that is from developing country with marked differences in patient profile, sedation protocols and resources. In most of the previous studies, as well as ours, infants have been found to be most vulnerable to complications, which are expected considering their decreased pulmonary reserve and increased airway resistance. Recurrent respiratory papillomatosis was an independent risk factor in our study which could be explained by the fact that these cause airway obstruction at multiple levels which can worsen this obstruction.

A distinctive aspect of our study was the inclusion of bronchoscopy findings as potential risk factors, with lower airway malacia emerging as an independent contributor to increased risk. Sedation choice did not

show a significant association with complications. In older children (> 5y) of the children who received propofol for sedation ($n = 16$), none had any complications. Propofol appears to be safe in older children. Despite a robust sample size and analysis of multiple risk factors, limitations of this study include the exclusion of post-procedure complications, high-risk patients, and the retrospective, single-centre design.

This study provides valuable insights into the safety of flexible bronchoscopy in pediatric patients and highlights specific risk factors that practitioners should be aware of to minimize complications.

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Table I Indications of Flexible Bronchoscopy

<i>Indication</i>	<i>Frequency</i>
Suspected airway malformation	308 (35.4)
Diffuse lung disease / suspected childhood interstitial lung disease	77 (8.8)
Suspected tuberculosis	98 (11.2)
Recurrent respiratory papillomatosis	25 (2.8)
Atelectasis	98 (11.2)
Persistent/recurrent pneumonia	121 (13.9)
Suspected foreign body aspiration	43 (4.9)
Immunodeficiency with pneumonia	27 (3.1)
Poorly controlled asthma	20 (2.3)
Diagnostic bronchoalveolar lavage	182 (20.9)
Hemoptysis	15 (1.7)
Others	23 (2.6)

Data is presented as n (%)

Multiple cases have more than one indication

Table II Factors Associated With Complications in Children Undergoing Flexible Bronchoscopy (n = 869) on Univariate Analysis

<i>Parameter</i>	<i>Complication (n = 59); n (%)</i>	<i>Odd's Ratio (95% CI)</i>	<i>P value</i>
Male	39 (66.10)	0.96 (0.55, 1.68)	0.914
Age < 1y	36 (61)	2.96 (1.73, 5.07)	<0.0001
Congenital heart disease	7 (11.8)	2.4 (1.05, 5.49)	0.037
Suspected airway malformation	29 (49)	1.88 (1.11, 3.18)	0.018
Immunodeficiency	3 (5)	1.75 (0.54, 5.6)	0.366
Diffuse lung disease / suspected childhood interstitial lung disease	2 (3.39)	0.34 (0, 1.3)	0.294
Chronic suppurative lung disease	2 (3.38)	1.01 (0, 3.97)	0.981
Collapse lung	5 (8.50)	0.71 (0.28, 1.77)	0.477
Suspected tuberculosis	3 (5.10)	0.4 (0.13, 1.24)	0.119
Recurrent respiratory papillomatosis	4 (6.78)	2.76 (0.96, 7.99)	0.06
Persistent/ recurrent pneumonia	6 (10.16)	0.68 (0.29, 1.59)	0.386
Suspected foreign body	4 (6.78)	1.43(0.51, 4)	0.508
Midazolam + fentanyl	56 (94.90)	0.91(0.29, 2.88)	0.891
Midazolam alone	3 (5.08)	2.11 (0.65, 6.9)	0.22
Propofol	0	0 (0-3, 2)	0.276
Upper airway malacia	19 (32.20)	2.03 (1.15, 3.59)	0.013
Lower airway malacia	20 (33.90)	2.81 (1.59, 4.95)	< 0.001
Oxygen by face mask /prongs	33 (55.93)	0.81 (0.47, 1.37)	0.443

^aRisk factors with P <0.1 were taken for multivariate analysis