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Use of the pediatric intensive care unit for post-procedural monitoring in young children following microlaryngobronchoscopy: Impact on resource utilization and hospital cost



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ABSTRACT

Objective: To assess the frequency of post-procedural complications, medical interventions, and hospital costs associated with microlaryngobronchoscopy (MLB) in children prophylactically admitted for pediatric intensive care unit (PICU) monitoring for age ≤ 2 years.

Methods: We performed a single-center, retrospective, descriptive study within a 44-bed PICU in a stand-alone, tertiary, pediatric referral center. Inclusion criteria were age ≤ 2 years and pre-procedural selection of prophylactic PICU monitoring after MLB between January 2010 and December 2015. Children were excluded for existing tracheostomy, if undergoing concurrent non-otolaryngeal procedures, or if intubated at the time of PICU admission. Primary outcomes were the development of major and minor procedural complications and medical rescue interventions. Secondary outcomes were hospital cost and length of stay (LOS).

Results: One hundred and eight subjects met inclusion criteria with a median age of 5.3 (IQR: 2.6–10.9) months. A majority (86%) underwent therapeutic instrumentation in addition to diagnostic MLB. There were no observed major complications or rescue interventions. Minor complications were noted within 5 h of monitoring and included isolated stridor (24%), desaturation $< 90\%$ (10%), and nausea/emesis (8%). Minor interventions included supplemental oxygen via regular nasal cannula (39%), single-dose inhaled racemic epinephrine (19%), single-dose systemic corticosteroids (19%), or high flow nasal cannula (HFNC) therapy (4%). Save for two cases of HFNC, interventions were completed or discontinued within 5 h. Median PICU LOS was 1.1 days and median cost was \$9650 (IQR: \$8235–\$14,861) per encounter. Estimated cost of same day observation in our post anesthesia care unit (PACU) following MLB without PICU admission is \$1921 per encounter.

Conclusions: In children ≤ 2 years of age prophylactically admitted for PICU observation, we did not observe severe complications or major interventions after MLB. Minor interventions and complications were noted early during post-procedural monitoring. PICU monitoring was substantially more expensive than same-day PACU observation. Young age as the sole criteria for prophylactic PICU monitoring after diagnostic or therapeutic MLB may be unjustified when comparable, cost-conscious care can be achieved in a PACU setting. Prior to pre-procedural selection of PICU monitoring, we recommend a broad contextual risk assessment including a review of comorbidities, operative plan, and intended anesthetic exposure.

1. Introduction

Pediatric microlaryngobronchoscopy (MLB) remains the gold standard procedure for upper airway evaluation in children [1–3]. It can be

used to diagnose, monitor and treat a number of conditions including subglottic stenosis, laryngomalacia, laryngeal clefts, airway polyps or cysts, vocal cord pathology, and foreign body aspiration [4]. While commonly completed at bedside or in ambulatory settings, MLB can be

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performed in the operating room under general anesthesia for children with high-risk comorbidities, complicated anatomy/physiology, to achieve greater patient comfort, improve operator control, or in anticipation of a higher level of post-procedural monitoring.

Complications after MLB have a reported incidence between 1.7 and 12.6% ranging in severity from epistaxis, hypoxemia, isolated stridor, and bronchospasm to pulmonary hemorrhage and pneumothorax [5–8]. Patient age as a risk factor for complications after MLB has been assessed in two recent investigations yielding contradictory findings. De Blic and colleagues assessed 1328 children undergoing outpatient flexible bronchoscopy and found those ≤ 2 years of age had higher frequency of complications (2.4% vs 1%) [6]. In a similar sized cohort study, DeBoer et al. found no differences in patient age between children who had unplanned post-procedural complications [7]. Consequently, there exists clinical equipoise resulting in practice variation in post-procedural monitoring for young children following MLB.

In our institution, surgical providers may elect to prophylactically admit to the pediatric intensive care unit (PICU) after MLB for monitoring by age criteria prior to procedure. We sought to describe the frequency of major complications and interventions in this population of children ≤ 2 years after MLB. In addition, we aimed to assess resource utilization (represented by frequency of medical interventions) and the financial burden of such prophylactic admissions on the healthcare system.

2. Materials and methods

2.1. Study design and setting

We performed a retrospective, descriptive study of children admitted to the Children's National Health System PICU following MLB between January 2010 and December 2015. Our 44-bed PICU admits approximately 150 postoperative otolaryngologic cases annually, where $\sim 20\%$ represent observation admissions following MLB. Study inclusion criteria were age ≤ 2 years, pre-procedural selection of prophylactic PICU monitoring, and admission directly from the operating room or post-anesthesia care unit (PACU). Exclusion criteria were presence of an existing tracheostomy, invasive ventilation maintained after MLB prior to PICU admission, or cases where concurrent non-otolaryngologic procedures were also performed. This study was reviewed and approved by our Institutional Review Board.

2.2. Study outcomes and definitions

Surgical admissions were identified retrospectively using the Virtual PICU Systems database (Virtual PICU Systems, LLC, Los Angeles, CA). Primary outcomes were development of minor complications (nasopharyngeal trauma, epistaxis, bronchospasm, isolated stridor, desaturation $< 90\%$, and nausea/emesis), major complications (pneumonia, pulmonary hemorrhage, pneumothorax, cardiopulmonary arrest, and mortality), minor interventions (nebulized albuterol, systemic dexamethasone, racemic epinephrine, and oxygen supplementation via simple mask, nasal cannula, or high-flow nasal cannula [HFNC]), and major interventions (non-invasive positive pressure ventilation, endotracheal intubation, thoracostomy tube placement, or use of Heliox[®]). Secondary outcomes included hospital lengths of stay (LOS) and total hospital costs. Additional clinical variables collected for descriptive purposes included gender, weight, existing comorbidities, Pediatric Index of Mortality-II Risk of Mortality % (PIM-2 ROM), prematurity, intraoperative steroid administration, and general operative data.

2.3. Hospital costs

Total hospital charges, including direct and indirect billing, were acquired from an independent, hospital billing dataset. Costs were

calculated using cost-to-charge ratios applied to our institution's fiscal year Medicare cost reports from the years 2010–2015 via previously validated methodology [9]. Costs estimates for post anesthesia care unit (PACU) monitoring were obtained using similar methods and institutional dataset from the year 2016. The PACU cost estimations included a summation of direct and indirect charges including facility fees, extended PACU observation, and charges for post-anesthetic and MLB care such as non-opiate analgesia, antiemetics, prophylactic antibiotics, acid suppressants, and nebulized corticosteroids.

2.4. Statistical plan

Descriptive data are reported throughout this manuscript as frequency with percentage, mean \pm standard deviation (SD) or median (IQR, interquartile range) depending on data type and variance. All analyses were completed using Stata[®] v15.1 software (StataCorp, College Station, TX).

3. Results

3.1. Sampling and general characteristics

Three hundred and forty-seven children were pre-selected for PICU monitoring following MLB during the study period. Of those, 108 met inclusion criteria with a majority excluded for age > 2 years (145/238, 61%) or post-procedural invasive ventilation (41/238, 17%). Median age was 5.3 (IQR: 2.6–10.9) months, weight was 6.3 (IQR: 4.8–7.9) kilograms, and PIM-2 ROM was 0.38 (IQR: 0.3–0.45) percent for patients meeting inclusion criteria. Supplementary descriptive and comorbidity data can be found in Table 1.

3.2. MLB data

Preexisting laryngomalacia (44%), stridor/noisy breathing (26%), or known subglottic stenosis (14%) were the most common indications for MLB (Fig. 1a). Therapeutic instrumentation, via rigid bronchoscopy, in addition to direct visualization of the airway occurred in 86% (93/108) of procedures. Instrumentation included supraglottoplasty (68/108, 63%), balloon dilation of subglottic stenosis (16/108, 15%), laser removal of laryngeal cysts or granulation tissue (8/108, 7%), and foreign body removal (1/108, 1%). Intraoperative corticosteroids were administered in 68% (73/108) of cases. Intraoperative findings and postoperative diagnoses are summarized in Fig. 1b. Routine post-operative management included prophylactic antibiotic administration (85/108, 79%), acid suppressive therapy (89/108, 82%), and nebulized corticosteroids (76/108, 70%).

Table 1
Study sample descriptive data.

Characteristics	Study Sample (n = 108)
Age, months ^a	5.3 (2.6–10.9)
Weight, kilograms ^a	6.3 (4.8–7.9)
Gender, male/female	61/39
PIM-2 ROM, % ^{a,b}	0.38 (0.3–0.45)
Preexisting comorbidities, n (%)	
Cardiac disease ^c	14 (13%)
Chronic lung disease	11 (10%)
Gastroesophageal reflux disease	36 (33%)
Genetic anomaly	6 (6%)
Prematurity	30 (28%)
Neurologic disease	6 (6%)
Obstructive sleep apnea	5 (4%)
Viral infection	3 (3%)

^a Quantitative data expressed as median (interquartile range [IQR]).

^b PIM-2 ROM = Pediatric Index of Mortality-II Risk of Mortality percentage.

^c Cardiac disease without hemodynamic significance or desaturation.

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