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PREDICTIVE UTILITY OF COLDS SCORE IN DEVELOPMENT OF LARYNGOSPASM IN CHILDREN UNDERGOING ELECTIVE ADENOTONSILLECTOMY AT KENYATTA NATIONAL TEACHING AND REFERRAL HOSPITAL, NAIROBI, KENYA

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ABSTRACT

Background: **Children with upper respiratory tract infections, including adenotonsillitis, are at a higher risk of perioperatively developing pediatric respiratory adverse events. Frequent inflammation of adenoids and tonsils can lead to serious complications with growth and developmental consequences, warranting their surgical removal. The COLDS score, developed by Lee and August, is a validated clinical screening tool designed to assist in the pre-anesthetic evaluation of children with upper respiratory tract infections.**

Objective: **To investigate the utility of the COLDS score in predicting a laryngospasm in children undergoing adenotonsillectomy at Kenyatta National Hospital (KNH), Nairobi, Kenya.**

Methods: **Eighty-four children aged 12 years and below were recruited in this single-center study, excluding those with uncorrected cardiac disease, gastroesophageal reflux disease, and neuromuscular disorders. Laryngospasm occurrence was the dependent variable, while patient and anesthetic factors were independent variables analyzed using STATA version 15. Descriptive statistics were applied to age, sex, body mass index, and upper respiratory tract infection data. The COLDS score and laryngospasm occurrence generated a receiver operating characteristic curve, with a cut-off value of 16.5 used to determine sensitivity, specificity, positive predictive value, and negative predictive value.**

Results: **The incidence of laryngospasm was 4/84 (4.8%). The sensitivity of COLDS score above and including 16.5 was 75.0% (95% CI, 19.4% - 99.4%) with specificity**

of 65.0% (95% CI, 53.5% - 75.3%) and overall accuracy of 65.5% (95% CI, 54.3% - 75.5%). The Positive Predictive Value (PPV) was 9.68% (95% CI, 5.4% - 16.9%) and Negative Predicitve Value (NPV) 98.1% (95% CI, 90.4% - 99.7%).

***Conclusion*: The preoperative risk assessment for laryngospasm of children prone to recurrent upper respiratory tract infections (URTIs) scheduled for adenotonsillectomy remains subjective. Based on the findings of our study, while the COLDS score may not be adequate as an independent diagnostic tool, it provides predictive potential for ruling out laryngospasm.**

INTRODUCTION

Adenoids and tonsils are lymphatic tissues in the nasopharynx with immunological significance. They trap bacteria and foreign material that enter through the nose and mouth. However, in children, frequent inflammation (adenotonsillitis) and enlargement of these tissues may result in sleep-disordered breathing (obstructive sleep apnea), chronic hypoxia, pulmonary circulation remodeling with pulmonary hypertension, and recurrent ear and sinus infections, negatively impacting growth and development, behavior, and academic performance. Recurrent adenotonsillitis and its complications are common indications for adenotonsillectomy.[1]

Pediatric respiratory adverse events (PRAEs) are a common perioperative complication in children, particularly in the presence of specific risk factors.[2-4] Risk factors associated with increased PRAEs can be surgery-related (airway procedures, appendectomy, cervical/anal dilatation, mediastinoscopy, thyroid surgery, esophageal surgery, and hypospadias repair), patient-related (young age, passive smoking, current or past history of eczema, obstructive sleep apnea (OSA), high body mass index (BMI), cystic fibrosis, neuromuscular disorders and gastroesophageal reflux disease or anesthesia-related (airway device used, type of induction agent, use of opioids, use of muscle relaxant and timing of extubation).[5-8]

Children scheduled for adenotonsillectomy are usually either recovering from or just beginning to develop an upper respiratory tract infection (URTI). URTIs are significant risk factors for developing PRAEs, including breath holding, persistent cough, bronchospasm, reflex partial or complete airway obstruction (laryngospasm), and desaturation.[7] An unrecognized or untreated laryngospasm can rapidly cause patient deterioration, resulting in cardiorespiratory arrest and death.

The readiness and fitness of children prone to URTIs for anesthesia are controversial. Each practitioner gauges their willingness to accept the risks based on prior experience. COLDS scoring tool shown in Table 1 below is a screening tool developed by Lee and August and published in 2014 to aid in the pre-anesthetic evaluation of children with URTIs.[9] The tool has five components based on the acronym: **C** - *C*urrent signs and symptoms, **O** - *O*nset of symptoms, **L** - Presence of *l*ung disease, **D** - Airway *d*evice used, and **S** - type of *s*urgery. Each component is assigned a score to obtain a total score of between 5 and 25. The higher the score, the greater the risk of developing PRAEs.

At present we have no objective scoring tool used to assess preoperative fitness of children with URTIs presenting for

adenotonisillectomy at Kenyatta National Hospital. Our study investigated the utility of the COLDS score in predicting a laryngospasm in children undergoing adenotonsillectomy at Kenyatta National Hospital (KNH).

Table 1

COLDS scoring tool by Lee and August[9]

	1	**2**	**5**
C Current signs/symptoms	None	Mild Examples: parents confirm URTI and/or congestion, rhinorrhea, sore throat, sneezing, low fever, or dry cough	Moderate/Severe Examples: Purulence, wet cough, abnormal lung sounds, lethargy, 'toxic' appearance, or high fever
O Onset	> 4 weeks ago	2-4 weeks ago	< 2 weeks ago
L Lung disease	None	Mild Examples: Hx of Respiratory Syncitial Virus, mild intermittent asthma, Chronic lung disease if > 1 year old, loud snoring, or passive smoker	Moderate/Severe Examples: Moderate persistent asthma, infant with chronic lung disease, obstructive sleep apnea, or pulmonary hypertension
D Airway device	None or facemask	Supraglottic airway	Tracheal tube
S Surgery	Other (including ear tubes)	Minor airway Examples: Adenotonsillectomies, Nasolacrimal duct probing, flexible bronchoscopy, and dental extractions	Major airway Examples: Cleft palate, rigid bronchoscopy, and maxillofacial procedures

METHODS

We carried out a single centre, prospective, observational, cross-sectional study between March and May 2023 at the Kenyatta National Hospital, a tertiary-level national teaching and referral hospital. We calculated a sample size of 84 patients using the Fishers formula based on the proportion of children scheduled for adenotonsillectomy for the preceding three years, adding 15% to account for attrition and missing data.[12] We included all children 12 years and below for elective adenotonsillectomy.

We excluded children with uncorrected cardiac disease, gastroesophageal reflux disease, and neuromuscular disorders. We excluded children with these conditions because they were not part of the parameters assessed on the COLDS score and would be potential confounding variables affecting the signs used to diagnose a laryngospasm, such as decreasing oxygen saturation and heart rate.

The dependent variable was the occurrence of laryngospasm, which was recognized by clinical features such as stridor, tracheal tug, lower chest wall indrawing, desaturation, bradycardia, cyanosis, loss of end-tidal carbon dioxide tracing, or cardiac arrest. The independent variables were patient factors (age, sex, BMI, and presence of URTI) and anesthetic factors (airway device used, type of induction agent, use of opioids, muscle relaxant, and timing of extubation). We measured children's weights using a calibrated weighing scale and heights using a headboard to allow for the calculation and categorization of BMI. For children over 2 years, we used a BMI calculator, and for children under 2 years old, we referred to growth charts, as per the guidelines of the Centers for Disease Control and Prevention (CDC).[13-15] Obstructive sleep apnea was assessed using a validated 8-component I'M SLEEPY questionnaire for use in children, where OSA was defined as a score of more than or equal to 3.[16]

This study was approved by the Kenyatta National Hospital-University of Nairobi Ethics and Research Committee (P694/08/2022), National Commission for Science, Technology and Innovation (NACOSTI/P/23/23378), Kenyatta National Hospital Research Department and the Department of Anesthesia, University of Nairobi. Informed consent was obtained from the legal guardians of all participants.

We collated data from paper-based and digital KOBO toolbox (Kobo, Inc. ATTN: Legal, 37 Highland Ave, Cambridge MA, 02139) questionnaires into Microsoft Excel (1 Microsoft Way, Redmond, WA). We then analyzed the cleaned and sorted data using STATA version 15 (4905 Lakeway Drive, College Station, Texas 77845-4512 USA). We analyzed variables such as age, sex, BMI, and presence of URTI using descriptive statistics in the form of mean and percentages. The COLDS score and laryngospasm occurrence generated a receiver operating characteristic curve (ROC curve), with a cut-off value of 16.5 used to determine sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

RESULTS

Of the 87 patients recruited, 3 had incomplete records and were not included in the analysis. Thus 84 patients were included in the study.

Demographic and clinical characteristics of patients undergoing elective adenotonsillectomy.

47 (56%) of the patients were female patients. The largest age group was 0-5 years with 52(62%) patients. 27 (32.1%) were obese, and 98.8% of patients were classified as having obstructive sleep apnea. At the time of the procedure 26 (31%) of patients had an active URTI, while 31(37%) patients had it in the 2 weeks prior to surgery. (See Table 2)

Table 2

Demographic and clinical characteristics of patients undergoing elective adenotonsillectomy

Variable	**n (%)**
Sex	
Male	37(44.1%)
Female	47(56%)
Age group	

0 to 5 years		52(62%)
6 to 10 years		30(35.7%)
>10 years		2(2.4%)
BMI categoriz		
Healthy	37(44.1%)	37(44.1%)
Obese		
Overweight	27(32.1%)	27(32.1%)
Underweight	Jjjhhh	16(19.1%)
		4(4.8%)
Presence of U		
Current	26(31%)	26(31%)
Within the pa		
More than 4 w	31(37%)	31(37%)
		27(32.1%)

Anesthetic factors of the patients undergoing elective adenotonsillectomy

For all the 84 patients analyzed, anesthesia was induced by sevoflurane inhalation followed by airway instrumentation and management with endotracheal intubation after administration of opioid (fentanyl) and a muscle relaxant (atracurium). At the end of the procedure, all patients were extubated awake after full emergence from anesthesia.

Incidence of laryngospasm among patients undergoing elective adenotonsillectomy

Table 3

Incidence of laryngospasm among patients undergoing elective adenotonsillectomy

Laryngospasm	Frequency	Percent	95% CI for prevalence
Present	4	4.8%	1.9% - 11.6%
Absent	80	95.2%	

We found a 4.8% incidence of laryngospasm in pediatric patients undergoing adenotonsillectomy.

Receiver operating characteristic (ROC) curve for determining COLDS score cut-off values

The COLDS score and the definite clinical outcome of laryngospasm were used to generate the ROC curve and determine the cut-off value based on sensitivity and specificity. The area under the curve was examined for significance.

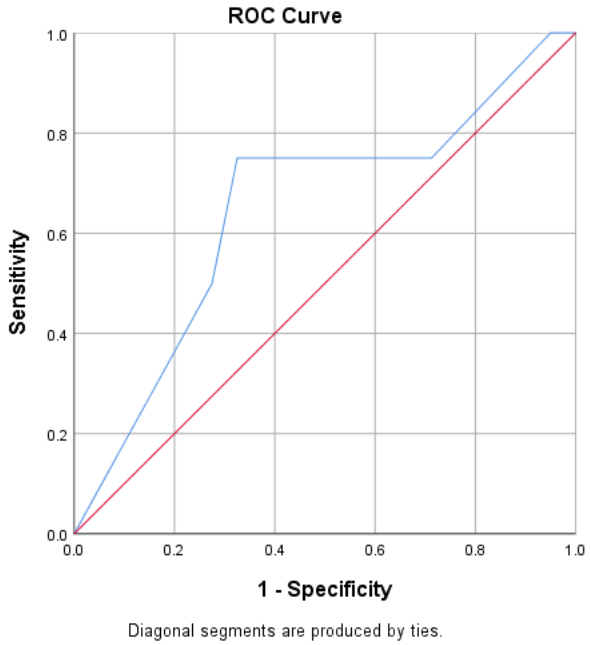

Figure 2: Receiver operating characteristic curve for determining COLDS score cut-off values

Table 4

COLDS score cut-off values determined by sensitivity and specificity of AUC under ROC curve

Area Under the Curve					
Test Result Variable(s)	**Area**	**Std. Error**	**Asymptotic Sig.**	**Asymptotic 95% Confidence Interval**	
				Lower Bound	**Upper Bound**
COLDS score	0.648	0.150	0.318	0.354	0.942
	Cut off	**Sensitivity**	**1-Specificity**		
COLDS score	16.5	75.0%	35.0%		

The value for the area under the curve (AUC) for the COLDS score is acceptable at 0.648, which did not achieve statistical significance (p=0.318).

Sensitivity and specificity of COLDS score in predicting laryngospasm

Table 5

Sensitivity and specificity of COLDS score in predicting laryngospasm

		Laryngospasm				
		Yes	**No**	**Positive Predictive Value**	**Negative Predicitve Value**	
Outcome	≥16.5	3	28	9.68%		
	<16.5	1	52		98.1%	
	Sensitivity	75.0%				

	Specificity		65.0%			
	Accuracy					65.5%

The results in Table 4 show the sensitivity, specificity, and accuracy of COLDS score in predicting laryngospasm using the cut-off value 16.5.

The sensitivity of the cut-off value was 75.0% (95% CI, 19.4% - 99.4%), specificity of 65.0% (95% CI, 53.5% - 75.3%), and overall accuracy of 65.5% (95% CI, 54.3% - 75.5%). The positive predictive value (PPV) was 9.68% (95% CI, 5.4% - 16.9%), and the negative predictive value (NPV) was 98.1% (95% CI, 90.4% - 99.7%).

DISCUSSION

The fitness of children prone to URTIs for anesthesia is controversial and provider-dependent. There are no objective guidelines at the hospital on determining the patients' fitness for surgery and anesthesia. Laryngospasm is a common complication with a high potential for morbidity and mortality, a more objective way of assessing patients preoperatively to enhance patient safety is warranted. COLDS score has been previously validated in the context of all PRAEs in children scheduled for elective surgeries.[10-11]

There was no gender predominance in our study. Most of the study participants were below 10 years old. These findings compared well with those of similar studies elsewhere.[17] The young age of surgery may be attributed to early recognition, follow-up, and scheduling for surgery once complications such as recurrent URTIs and OSA are diagnosed.

More than half of the children either had an active URTI at the time of surgery or were recovering from one. A significant number of children also had a history of infections more than 10 times a year. School-going children are most likely to be exposed to recurrent infections due to the close proximity and reduced precautionary care with a possibly still developing immune system.[18-19] The history of more than 10 infections yearly, in combination with all children but one having OSA, was noted to be in keeping with the established indications for the procedure.[20]Interestingly, just less than half the patients were of normal BMI, therefore possibly indicating the severity of obstruction from adenotonsillar hypertrophy rather than as a result of body habitus. Anesthetic factors were uniform for all patients due to standard adenotonsillectomy anesthesia provider practices in our facility.

The incidence of laryngospasm in our study was much lower than anticipated at 4.8%. There have been incidences as high as 18-25% documented in other studies.[21-22]The low incidence of laryngospasms may be explained by the Ear, Nose, and Throat surgeons being aware of the perioperative complications associated with proceeding to surgery with certain risk factors. As a result, the surgical team screened the patients relatively well before scheduling the procedure. The incidence of laryngospasm will likely be variable based on an individual provider's skills and competencies, and the study period of 3 months probably reflected the skills of the specific anesthesia providers and the risk of laryngospasm during that time.

For the COLDS score, a higher score signified an increased risk of developing laryngospasm. The area under the curve (AUC) values of a receiver operating characteristic (ROC) curve range from 0.5 (no diagnostic ability) to 1.0 (perfect diagnostic ability). Our data suggested that the COLDS score has a moderate

diagnostic ability. The AUC of 0.648 found in the current study might not be adequate as a diagnostic tool but is adequate as a predictive tool.

The test COLDS score for pediatric patients undergoing adenotonsillectomy at the Kenyatta National Hospital yielded moderate sensitivity and specificity. For a test to be useful, sensitivity and specificity combined should be at least 1.5 (ranging between 1- not useful and 2- very useful).[23] In our study, this value was at 1.4. The positive predictive value (PPV) was low, indicating that a positive test result, i.e., COLDS score 16.5 and more, was not very reliable for predicting the occurrence of laryngospasm, potentially due to a low incidence of the condition in the population tested. The negative predictive value(NPV), however, was very high, indicating that a negative test result, i.e., a COLDS score of less than 16.5, was highly reliable for ruling out the likelihood of laryngospasm occurring. These findings were in keeping with those in the study by Lee LK et al.[10], where they noted that the score was not useful in predicting laryngospasms, but it is important to note that from our findings, a score of less than 16.5 can rule out a laryngospasm.

CONCLUSION

In conclusion, the assessment of children prone to recurrent URTIs for adenotonsillectomy remains subjective to the anesthesiologist reviewing the patient, particularly in the absence of objective guidelines at the hospital. The COLDS score, previously validated for predicting perioperative respiratory adverse events in children undergoing elective surgeries, presents a potential tool for such assessments. According to the findings of our study, while the COLDS score may not be adequate as an independent diagnostic tool, it provides predictive potential, particularly for ruling out laryngospasm.

Limitations

The results of our study may not be generalizable because it was a single-center study. There was the likelihood of recall bias by parents while answering the questionnaire, particularly regarding the number of URTIs the children may have had in the past year.

RECOMMENDATIONS

We recommend the use of the score in this population of patients, with caution, to rule out the possibility of laryngospasms. However, vigilance is still required during anesthesia to rapidly detect and manage a laryngospasm. We recommend a multicenter study to make the results more generalizable.

Author's Contribution Statement

Pallavi S. Rajani: Conceptualization; Data Curation; Formal Analysis; Investigation; Methodology; Writing (Original Draft Preparation); Project Administration. **Fred Sitati:** Data Curation; Formal Analysis; Supervision; Writing (Review and Editing). **Patrick Olang':** Methodology; Validation; Writing (Review and Editing). **Timothy Mwiti:** Conceptualization; Formal Analysis; Methodology; Validation; Writing (Review and Editing), Project Administration.

Conflict of Interest

Authors declares no conflict of interest.

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