Preoperative Predictors of Poor Laryngoscope Views in Pediatric Population Undergoing Cardiac Catheterization

Abstract

Background: The primary objective of this study was to identify pre-anesthetic airway assessment parameters that would predict Cormack and Lehane grade III and IV laryngoscopy views in pediatric patients undergoing cardiac catheterization procedures. The secondary end points were to identify factors that would contribute to difficult laryngoscope views in this subset of patients. **Settings and Design:** Prospective observational study performed at a single tertiary cardiac care center. **Materials and Methods:** 199 children below 5 years of age undergoing elective cardiac catheterization were included. Pre-anesthetic airway assessment was done by modified Mallampati grading, lower lip to chin distance [LCD], tragus to mouth angle [TMA], thyromental distance [TMD], neck circumference [NC], and the ratio of height to thyromental distance [RHTMD]. Demographic data including American Society of Anesthesiologists physical status [ASA PS] were recorded for each child. Receiver Operating Characteristic curves were plotted and Areas Under the Curve were measured to identify the best cut off values for each of the airway evaluation method that would predict poor laryngoscopy views as well as assess their accuracy in doing so. **Results:** LCD, TMD and low body mass index were found to have good sensitivity, specificity and accuracy in predicting Grade III and IV laryngoscope views. ASA PS grade III and above patients had a significantly higher incidence of poor laryngoscope visualization. **Conclusions:** LCD, TMA, TMD, NC, RHTMD and BMI could all be used combinedly as screening tools during pre-anesthetic airway evaluation for predicting difficult laryngoscope views in children. Among these, LCD, TMD along with low body mass index might have better accuracy.

Keywords: *Anesthesia, cardiac catheterizations, child, forecasting, infant, intratracheal/methods, intubation, newborn*

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Introduction

Unanticipated difficult tracheal intubation in pediatric patients can be a challenge for pediatric anesthesiologists especially when procedures are done in remote hospital locations. After allowing for stratification for demographic risk factors, a higher incidence of poor direct laryngoscopic view was encountered in cardiac surgery patients compared with general surgery patients.[1] The reported incidence of poor laryngeal views in patients younger than 1 year of age was 3.5%, and the overall incidence was significantly higher in children than in the older patients (5.6% vs. 1.7%).[1] A difficult airway scenario can have many implications for pediatric patients undergoing cardiac catheterization. In addition to the underlying cardiac lesions, a difficult tracheal intubation could impact the postprocedural course. Back up intensive care beds are not

routinely requested for pediatric cardiac catheterizations, and an unanticipated admission due to a difficult airway would lead to disruption in the smooth functioning of the unit. Hence, preanesthetic predictors for difficult intubation gain special prominence in this subset of patients. The hypothesis of this study was that in children none of the routine preanesthetic airway assessment parameters that are applicable in adults would predict Grade III and IV laryngoscope views by Cormack and Lehane classification. The primary objective of this study was to identify if any of the routine preanesthetic airway assessment maneuvers that are commonly used would predict poor laryngoscope views in pediatric patients with cardiac lesions. The secondary objectives were to identify if factors such as age, sex, body mass index (BMI), physical status grade, type of underlying cardiac lesion, history of difficult intubation, and type of general

anesthesia induction technique would be associated with Grade III and IV laryngoscope views in these patients.

Materials and Methods

After obtaining the Institutional Medical Ethics and Scientific Research Committee approval (MESRC#11/2014) as well as an informed consent from the parents, 199 children (newborns to 5 years of age) undergoing elective cardiac catheterization were prospectively included in this observational study. Those children that had tracheal intubation performed as an emergency procedure or done by intensivists were excluded from the study. Before the procedure, the parents/attendants of the children were interviewed for any information that would suggest the possibility of difficult airway access such as history of snoring, mouth breathing, hoarse voice, prior episode of difficult intubation and prior surgery or radiation treatment to head and neck. Demographic data included age, sex, and BMI. The American Society of Anesthesiologist physical status (ASA PS) was also recorded. During the pre-anesthetic assessment, the same investigator obtained lower lip to chin distance (LCD), tragus to mouth angle (TMA), thyromental distance (TMD), neck circumference (NC), and the ratio of height to TMD (RHTMD) in all children. Samsoon and Young's modification of Mallampati grading was used to assess the airway in children that could cooperate.

The children were grouped based on the age as follows: (1) <30 days, (2) from 31 days to 12 months, (3) from a day after 12 months to 24 months, (4) from a day after 24 months to 36 months, and (5) from a day after 36 months up to 60 months.

Following the preanesthetic assessment, the children were with weight-adjusted dose of oral midazolam which was as per the institutional protocol. In the cardiac catheterization laboratory, the general anesthesia was administered by one of three experienced pediatric anesthesiologists (with a minimum annual anesthesia caseload of 200 children per year including at least one infant/per week). These anesthesiologists were not apprised of the preanesthetic airway assessment findings. General anesthesia was induced by mask inhalation technique using oxygen and sevoflurane when there was no intravenous access. When intravenous access was available, general anesthesia was administered with sleep dose of propofol or thiopentone, midazolam, and fentanyl depending on the preference of the attending anesthesiologist and the hemodynamic status of the patient. Once the children were asleep, muscle paralysis was achieved with cisatracurium (0.2 mg/kg). Attempts at tracheal intubation were made after 3 min of ventilation following muscle relaxant administration and placing the head of the child in a neutral position. The laryngeal view during direct laryngoscopy using an appropriate size Macintosh blade was graded based on the Cormack and Lehane classification In general, Mackintosh blades size "0" was used for newborns

and infants, size "1" up to 2 years of age and size "2" up to 5 years of age. However, the selection of the size of the blade was left to the discretion of the attending anesthesiologist. Laryngeal views Grade III and Grade IV were considered as markers for possible intubation difficulty.

The incidence of Grade III and Grade IV laryngeal views in relation to age, sex, BMI, ASA PS grade, underlying cardiac lesion, prior history of difficult tracheal intubation and type of anesthetic induction technique was analyzed. The relationship between Grade III and Grade IV laryngeal views and preanesthetic airway assessment components were evaluated. The mean values of TMA, LCD, NC, TMD, and RHTMD that corresponded with Grade III and Grade IV laryngeal views were ascertained.

Statistical analysis

The data collected were analyzed using MedCalc Statistical Software version 17.8 (MedCalc Software bvba, Ostend, Belgium; http://www.medcalc.org; 2017). The descriptive analysis of the categorized variables is presented as proportions, and continuous variables are presented as mean and standard deviation. The Chi-square test was used to study the association between preanesthetic airway assessment tools and Grade III and Grave IV laryngeal views. The receiver operating characteristic (ROC) curves were computed for LCD, TMA, TMD, NC, RHTMD, and the BMI to determine the best cutoff values for each of the preanesthetic airway assessment methods. The sensitivity and the specificity were also computed along with the positive predictive and the negative predictive values for each assessment technique. The area under the curve (AUC) was calculated for each assessment method, and a value above 0.8 was considered accurate in predicting difficult laryngoscopy views.

Results

Two hundred and ten children below 5 years of age undergoing elective cardiac catheterization procedures were initially recruited for the study. However, 11 children were excluded as data of laryngeal views was unavailable. One hundred and ninety-nine children completed the study. The demographic data are shown in Table 1. Based on the Cormack and Lehane classification, 7 out of 199 children (4%) had Grade III and IV laryngeal views. The incidence of Grade III and IV laryngeal views decreased from 13.3% to 2.8% as the age of the children increased from newborn period to 60 months of age through this observation was not statistically significant. Sex, underlying cardiac lesion, history of prior difficulty in tracheal intubation, type of induction agent appeared to have no impact on the laryngeal views. Children in ASA PS Grades III and IV had a significantly higher incidence of difficult laryngoscopy views compared to patients in ASA PS Grades I or II ($P = 0.003$).

During preanesthetic examination, airway assessment based on modified Mallampati classification could be done only

in 99 patients (49.7%) who were above 3 years of age. Airway assessment by modified Mallampati classification could not predict poor laryngeal views [Table 2].

The ROC curves showed good correlation between LCD, TAM, TMD, NC, RHTMD, low BMI values, and Grade III and IV laryngoscope views [Figure 1]. Table 3

shows the AUC and the cutoff values based on ROC for these preoperative airway assessment methods. For example, ROC for LCD suggested that the best cutoff value was ≤2.2 cm with an AUC 0.879. If a child had LCD value which was equal to or <2.2 cm, the sensitivity of LCD for predicting Grade III and IV laryngoscope views was very high with a sensitivity of 85.7% (95%
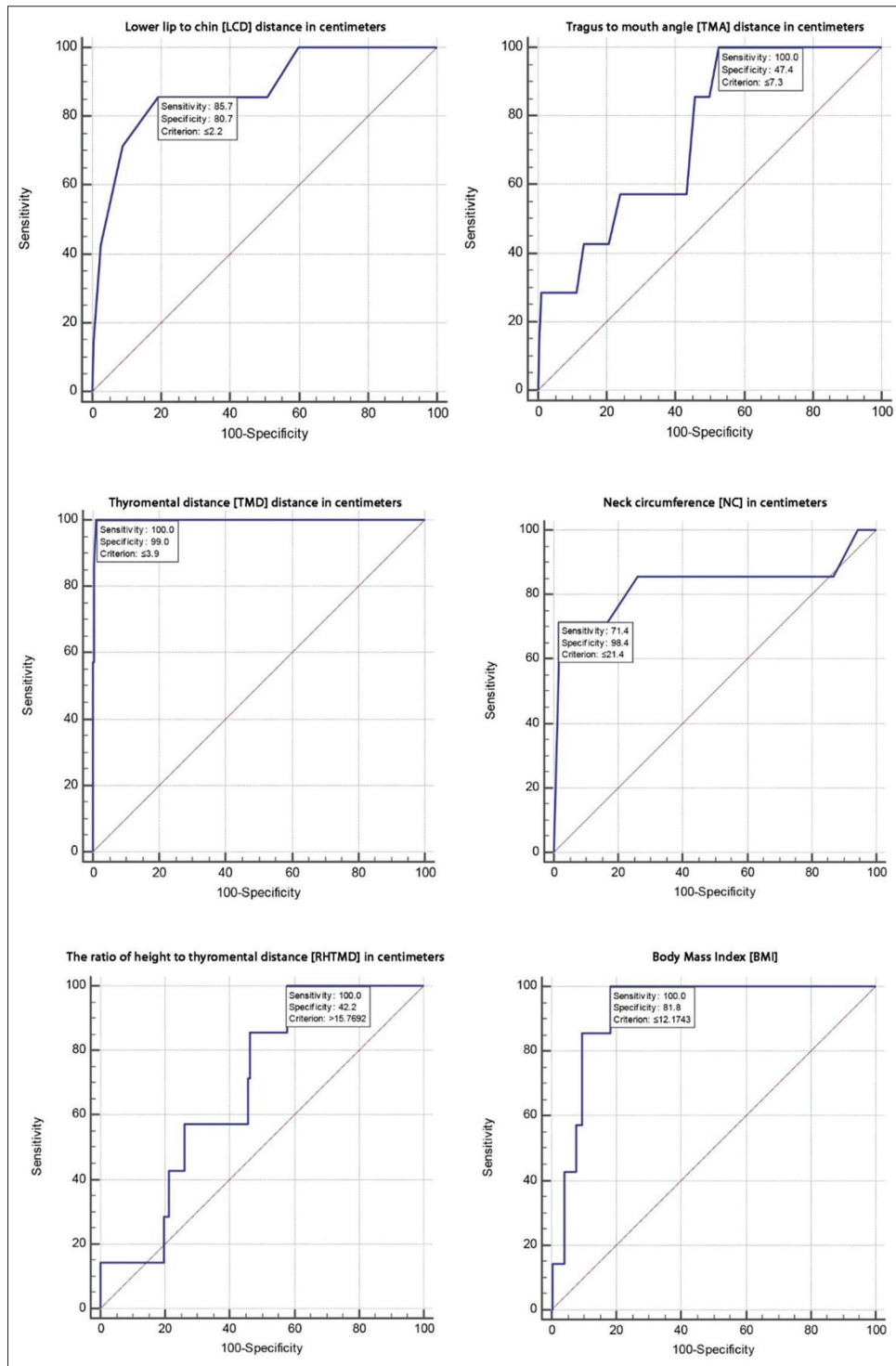

Figure 1: Receiver Operating Characteristic curves for lower lip to chin distance, tragus to mouth angle, thyromental distance, neck circumference, ratio of height to thyromental distance and body mass index showing the best cutoff values and sensitivity and specificity of each individual assessment tool

Table 1: Demographic data

Variable	Cormack and Lehane grading of laryngoscope view		P
	I and II, *n* (%)	III and IV, *n* (%)	
Age			
<30 days	13 (86.7)	2 (13.3)	0.275
31 days-12 months	57 (96.6)	2 (3.4)	
A day after 12 months-24 months	52 (96.3)	2 (3.7)	
A day after 24 months-36 months	35 (100.0)	0 (0)	
A day after 36 months-60 months	35 (97.2)	1 (2.8)	
Sex			
Male	100 (96.2)	4 (3.8)	1.000
Female	92 (96.8)	3 (3.2)	
ASA PS			
ASA Grade I, II	89 (100.0)	0 (0)	0.003**
ASA Grade III, IV	103 (93.7)	7 (6.4)	
Underlying cardiac lesion			
Atrial septal defects for device closure	52 (98.1)	1 (1.9)	0.508
Ventricular septal defects for device closure or diagnostic catheterizations	35 (92.1)	3 (7.9)	
Patent ductus arteriosus for simple occlusion or stenting in complex congenital lesions	41 (97.6)	1 (2.4)	
Others: Pulmonary/tricuspid atresia, tetralogy of Fallot, congenital aortic stenosis, etc.	64 (97.0)	2 (3.0)	
History of difficult intubation			
Yes	2 (100.0)	0 (0)	1.00
No	190 (96.4)	7 (3.6)	
Induction agent			
Inhalation agent	177 (96.2)	7 (3.8)	1.00
Intravenous agent	15 (100.0)	0 (0)	

**Chi-square exact test. ASA PS: American Society of Anesthesiologist physical status

Table 2: Relationship between preanesthetic modified Mallampati classification and poor laryngoscopy views by Cormack and Lehane classification (Grades III and IV)

Variable	Cormack and Lehane grading of laryngoscope view		P
	I and II, *n* (%)	III and IV, *n* (%)	
Modified Mallampati Classification, (*n*=99 children)			
Class I	58 (98.3)	1 (1.7)	0.865*
Class II	35 (97.2)	1 (2.8)	
Class III	4 (100.0)	0 (0)	

*Chi-square test

confidence interval [CI]: 42%–100%) and specificity of 80.7% (95% CI: 74%–86%). The positive predictive value was nearly 14%, and the negative predictive value was 98%. Therefore, LCD could be considered as a reliable tool for predicting difficult laryngoscope views [Table 3]. In addition to LCD, TMD, and low BMI exhibited sensitivity and specificity above 80% with AUC above 0.8. The negative predictive value was very high for all the 6 values.

Discussion

An attempt at eliciting a correlation between preanesthetic airway assessment maneuvers and actual difficult laryngoscope views defined as Grade III and IV by Cormack and Lehane classification was made in this prospective observational study in pediatric patients <5 years of age undergoing cardiac catheterization procedures. The overall incidence of difficult laryngeal views was 4%. Of the preanesthetic values, LCD, TAM, TMD, NC, RHTMD, and low BMI could correlate with difficult laryngoscope views. LCD, TMD, and BMI had high specificity (>85%) and sensitivity (>80%) with AUC above 0.8 indicating that these three values could be helpful in identifying difficult laryngoscope views in pediatric cardiac patients. The hypothesis that none of the preanesthetic airway assessment predictors applicable in adults would predict difficult laryngeal views in pediatric patients was rejected.

The incidence of difficult laryngoscopy during pediatric cardiac surgery was twice as high as in other pediatric surgical specialties.[2] Difficult tracheal intubation is a dreaded complication for any pediatric anesthesiologist and pediatric cardiac patients are at an increased risk due to their underlying congenital heart defects, compromised

Table 3: Receiver operating characteristic curve values, area under the curve values along with the best cutoff values for each of the pre-anesthetic airway assessment methods

Variable	Cut off value	Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value	Negative predictive value	Area under the curve	*P*
LCD	≤2.2 cm	85.71 (42.13-99.64)	80.73 (49.04-69.88)	13.95	98.21	0.879	<0.0001
TMA	≤7.3 cm	100.0 (59.04-100)	47.40 (40.16-54.71)	6.48	100.0	0.748	0.0032
TMD	≤3.9 cm	100.0 (59.04-100)	98.96 (96.29-99.87)	77.78	100.0	0.997	<0.0001
NC	≥21.4 cm	71.4 (29.04-93.33)	98.4 (95.50-99.68)	62.50	98.95	0.833	0.0086
RHTMD	≥15.77	100.0 (59.04-100)	41.67 (34.61-48.98)	5.88	100.0	0.690	0.0164
BMI	≤12.17	100.0 (59.04-100)	81.77 (75.57-86.96)	16.67	100.0	0.923	<0.0001

CI: Confidence interval, TMA: Tragus to mouth angle, TMD: Thyromental distance, NC: Neck circumference, RHTMD: Ratio of height to thyromental distance, BMI: Body mass index, LCD: Lower lip to chin distance

pulmonary perfusion, and hemodynamic response characteristics that can result in a faster desaturation than in healthy children. In addition, preoxygenation might be difficult in these patients resulting in an increased risk of severe hypoxemia during anesthesia induction.[2] Toward this end, this study attempts to identify preanesthetic airway assessment predictors that can help pediatric cardiac anesthesiologists anticipate difficult laryngoscope views to enable them to be better prepared.

The most frequent cause of poor laryngoscope views in pediatric cardiac patients is an anterior larynx.[3] We also found that an anteriorly placed larynx to be the primary reason for poor laryngoscope views and not the syndromes that are associated with congenital cardiac lesions.

It has been suggested that direct laryngoscopy is most effective when the shoulders and head are on a flat surface, and the neck is fully extended.[4] In this study, the head of all pediatric patients for cardiac catheterization was placed in neutral position to avoid any factor that could affect the laryngoscope view no roll was inserted under the shoulder. No external laryngeal manipulation was made during the initial laryngeal view assessment. The pre-anesthetic evaluation was performed by the same operator. Laryngeal view evaluation was done by pediatric cardiac anesthesiologists with similar experience.

We found that the incidence of Cormack and Lehane Grade III and IV laryngeal views in infants was 5.4% (4/74) that is marginally higher than what was reported earlier.[5] This study proposed that ASA PS III and IV was associated with a significantly increased incidence of difficult laryngoscopy views (*P* = 0.003) which is similar to earlier findings of Heinrich and colleagues.[5]

An earlier meta-analysis suggested that the modified Mallampati test had good accuracy as compared to the original Mallampati test in predicting a difficult airway.[6] The airway was assessed by modified Mallampati grading in 99 patients but could not predict a difficult laryngoscope view in our patients.

In pediatric population, the distances from the lower lip to chin and ear tragus to mouth had a direct association with difficult airways although there were no apparent cutoff points to predict difficult laryngoscopy, for any of the distances.[7] The present study attempts to provide cut off values for both preanesthetic airway assessment tools. LCD of ≤2.2 cm was associated with poor laryngoscope views.

TMD measurement is commonly used to predict difficult intubation in adults, although reports of the cutoff distance vary in the literature. Values such as the width of three fingers (mean 5.9 cm) and 4 cm have been was suggested as a cutoff value for predicting a difficult airway.[8,9] Our study showed that in children, the cutoff values are ≤3.9 cm for poor laryngoscope views.

Increasing NC was reported to be a predictor of potential intubation problems in adult patients.[10] However, absolute values for adults or pediatric patients are not available in the literature. NC of ≥21.4 cm was found to be a good predictor of difficult laryngoscopy in this study (*P* < 0.001) (we need to see the subgroup analysis).

A multivariate analysis suggested RHTMD to be a useful screening test for difficult laryngoscopy with a cutoff value of ≥23.5 correlating with difficult laryngoscopy.[11] Our study demonstrated that there is good correlation between the RHTMD and a cut off vale >15.77 correlated with difficult laryngoscopy views in pediatric patients below 5 years of age.

Low BMI was shown to be associated with difficult laryngoscopy.[5] A low BMI of ≤12.17 was associated with poor laryngoscope views in the present study.

The limitations of the study include:
1. The sample size which can be considered small
2. The laryngoscope findings were the result of a subjective view of the anesthesiologists
3. It can be argued that the cut off values cannot be extrapolated across different age groups. Hitherto no cutoff values have been suggested in pediatric cardiac patients. In this study, by restricting the patient population to be below 5 years of age probably, it can be said that these cut off values could serve to some extent as warning signs for the possibility of difficult laryngoscope views.

The strengths of this study include:

1. It is a prospective study performed in pediatric cardiac patients undergoing cardiac catheterization procedures that are most often diagnostic or palliative in nature and rarely curative. These patients seldom have the luxury of postoperative intensive care back up
2. Direct laryngoscopy was performed initially by all anesthesiologists with an appropriate size Macintosh blade. After first laryngoscope visualization, modification of blades was allowed
3. Initial attempts at intubation were performed with the head kept in neutral position. Subsequently, manipulations were made at the discretion of the anesthesiologist.

Conclusion

LCD, TMA, TMD, NC, and RHTMD had good negative predictive values and can all be used as screening tools during preanesthetic airway evaluation for predicting difficult laryngeal views in children undergoing cardiac catheterization procedures. LCD, TMD along with low BMI might have better accuracy in predicting poor laryngoscopy views. However, it is suggested that instead of relying on only a few, a combination of all the above preanesthetic airway assessment predictors might help in better prediction of poor laryngoscope views in children.

Acknowledgment

Financial support and sponsorship

Conflicts of interest

There are no conflicts of interest.

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