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Evaluation of "Difficult Airway Predictors in Pediatric Population" As a Clinical Investigation

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Abstract

Background: Preoperative evaluation of anatomical landmarks and clinical factors help identify potentially difficult airway. Till date there are no criteria or absolute guidelines that can be helpful in detecting difficult airway in pediatric population.

Aim: To find the predictors of difficult mask ventilation, difficult laryngoscopy and difficult intubation in pediatric population age 1-5 years. Setting and design a prospective study was conducted in 100 ASA grade I/II pediatric patients between 1-5 years, scheduled for surgery under general anesthesia. Patients with congenital upper airway malformations and those with neck or face swelling or scars were excluded from the study.

Material and methods: We assessed the usefulness of interincisor gap (IIG), oropharyngeal view with mouth wide open (without tongue protrusion), modified mallampati Class (MMP) , relationship of maxillary and mandibular incisor during normal jaw closure, neck circumference(NC) , thyromental distance (TMD), sternomental distance (SMD), ratio of height to thyromental distance as preoperative predictors of difficult mask ventilation , laryngoscopy and intubation.

Result: Mask ventilation was graded using difficult mask ventilation (DMV) grading, with DMV grade of 3 & 4 occurring in 3 patients (3%). Laryngoscopy was assessed using Cormack and Lehane (C&L) grading system which revealed 3 cases of CL grade III with no case falling under CL grade IV. Ease or difficulty in tracheal intubation was assessed using Intubation difficulty score (IDS) 40% cases showed mild difficulty (0<IDS >5) and 2% showed major difficulty (IDS>5).

Conclusion: Interincisor gap, neck cicumferance, sternomental distance was found to be predictors of difficult mask ventilation. Statistically significant correlation was found between difficult laryngoscopy and intubation. Age, best oropharangeal view and thyromental distance were found to be predictors of difficult larngoscopy and intubation. Analysis proved that mask ventilation became easier after administration of muscle relaxant and difficulty decreased after 3 years age.

Keywords: Difficult airway; Pediatric population; Mask ventilation; Laryngoscopy

Introduction

A difficult airway in a pediatric patient can be a stressful situation for all involved. A review of the pediatric closed claims cases stated most common causes of anesthesia related deaths were result of inadequate ventilation. Inadequate ventilation was a more common problem in children than in adults [1]. The usefulness of airway assessment (Table 2) has been verified by Rose and Cohen (1994) that it helps in identifying more than 98% of difficult airway [2]. Of particular note in the pediatric population, unlike adults, no fixed classifications exists which would help in determination of patients at risk of difficult BMV or intubation.

Difficult airway can be anticipated or unanticipated. Anticipated difficult airway includes congenital syndromes or anatomy and acquired anatomy like TMJ dysfunction or neck contracture. A common feature of many of these syndromes is micrognathia leading to difficult laryngoscopic visualization of glottis structure [3,4]. Mallampati classification does not accurately predict a poor view of glottis during direct laryngoscopy in pediatric population [5].

	AGE (years)	HEIGHT (meters)	WEIGHT (Kilogram)	BODY MASS INDEX (BMI)
Minimum	1.0	0.67	3.0	3.0
Maximum	5.0	1.20	20.0	23.1
Mean	3.0	0.9	12.7	14.8
Std. Deviation	1.4	0.13	3.5	2.6

Airway was assessed preoperatively and studied parameters are summarized in table 2, table 3, table 4

Table 1: Demographic parameters.

Some prefer the COPUR scale for evaluation of pediatric airway. This scale rates chin size, interdental opening, previous intubation or OSA, uvula visualization, and estimated range of motion of neck on a 4-point scale [6]. Scores above 10 predict difficult intubation. Our study was conducted in view of limited literature on airway assessment in children.

Aim of Study

Aim of our study was to evaluate various airway parameters in pediatric population likely to predict

1. Difficult bag and mask ventilation (BMV)

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	Interincisor gap (cm)	Tthyromental distance (cm)	Sternomental distance (cm)	Ratio of height to thromental distance (cm)	Neck circumferance (cm)
Number of patients	94	97	97	97	99
Minimum	2.0	3.0	8	10.70	21
Maximum	5.0	10.0	17	30.00	31
Mean	3.613	5.119	10.57	18.6148	24.29
Std. Deviation	0.66	0.93	1.5	3.12	1.83

Table 2: Parameters for airway assessment.

Best oropharyngeal view grade	Frequency	Percent
0	12	12.5
1	52	54.2
2	28	29.2
3	4	4.2
Total	96	100.0
Not assessed	4	

Table 3: Frequency and percentage of best oropharyngeal view grade and score.

2. Difficult laryngoscopy

3. Difficult intubation

Material and Methods

A prospective study was conducted after taking institutional review board approval (Maulana Azad Medical College, New Delhi) in 100 ASA grade I/II pediatric patients of either sex between 1-5 years scheduled to undergo elective surgery under general anesthesia. The children having a known difficult airway including congenital upper airway malformation, swelling in head and neck region, scars, dressing and were excluded from the study. An informed consent was taken from the parents/ guardians of the children. A detailed preoperative history especially in reference to airway was recorded. This included history of snoring, mouth breathing, recurrent upper respiratory tract infection, reactive airway disease, hoarse voice and prior surgery or radiation treatment to head and neck. Standard airway examination including interincisor gap, modified mallampati class (Samsoon and Young modification of mallampati class-MMP), mandibular protrusion, neck circumference, thyromental distance (TMD), sternomental distance (SMD) and neck movements was carried out. Since the study population had children between 1-5 years of age it was hypothesized that children might not protrude out the tongue for MMP assessment. We decided to study the best oropharyngeal view (BOV) (Table 3). Which would be? The method of assessment was similar to assessing MMP i.e., mouth wide open but without tongue protrusion. The grading criteria of the view were same as MMP.

Best oropharyngeal view grade

Grade 0

Grade 1

Grade 2

Grade 3

The patients were premedicated with oral midazolam 0.5 mg kg^{-1} 30 minutes prior to surgery. Anaesthesia was induced with sevoflurane in oxygen using anatomical face mask (size 0 for body weight <12kg and size 1 for body wt ≥12kg) with Jackson Rees modification of Ayres T-piece circuit. Intravenous line was secured and fentanyl 1.5 µg kg^{-1} was given intravenously. Spontaneous ventilation was allowed using sevoflurane 2-2.5% and nitrous-oxide 66% in oxygen. After 1 min of initial stabilization, bag mask ventilation (BMV) was assessed for a period of 2 min. The ease of mask ventilation was graded using difficult mask ventilation score as described by Kheterpal et al. [7].

Grade 1: Ventilated by mask

Grade 2: Ventilated by mask with oral airway/adjuvant with or without muscle relaxant

Grade 3: Difficult ventilation (inadequate, unstable, or requiring two providers) with or without muscle relaxant

Grade 4: Unable to mask ventilate with or without muscle relaxant

Suxamethonium 1.5 mg kg^{-1} was given to all patients with difficult mask ventilation grade I/II/III and mask ventilation was again assessed for 2 minutes using controlled ventilation. In case BMV was not possible after muscle relaxation, or SpO_2 fell below 92%, airway was secured by laryngoscopy and endotracheal tube placement. Laryngoscopy was carried out using appropriate size Macintosh blade and was assessed using Cormack and Lehane grading. Intubation was carried out using an uncuffed endotracheal tube (ETT) appropriate for age. The ease of intubation was graded using Intubation Difficulty Score (IDS) [8]. The time taken to intubate was considered from the insertion of laryngoscope blade in oral cavity to the delivery of first breath. Patient's Non invasive blood pressure (NIBP), ECG, temperature and SpO_2 were monitored throughout the procedure. Anesthesia was maintained as per requirement of the surgery following which anesthesia was reversed and patient shifted to post operative room.

Statistical analysis

Statistical analyses were performed using SPSS® version 15 (SPSS Inc, Chicago, IL). The data collected was summarized in terms of frequency (counts/percentage) for categorical variable and descriptive statistics in terms of minimum/maximum/S.D./Median/SEM for continuous variables. The association of significant predictors in preoperative stage for outcome parameter at intraoperative stage was carried out by:

1. Chi-square Test/Fisher exact Test was used to access association between qualitative data.

2. Pearson correlation coefficient (r)/Non parametric spearman rank correlation was applied to see significant correlation between preoperative and intraoperative variables.

All variables deemed to be significant in the full model fit (P<0.05) were established as independent predictors.

Sample size

The sample size was kept as 100 patients .This arbitrary figure was chosen as we could not find any study correlating the difficult airway predictors with BMV, laryngoscopic view or Intubation difficulty in children. We calculated the power of the sample size for various positive predictors retrospectively.

Results

100 patients between 1 to 5 years were studied and demographic profile is shown in table 1.

Modified Mallampati Class (MMP) (Tables 4 and 5) could be assessed only in 82 patients as 18 patients, all less than 3 years, didn't

MMP class	Frequency	Percent
1	29	35.4
2	46	56.1
3	7	8.5
Total	82	100.0
Not assessed	18	

Table 4: Mallampati class.

	Number of subjects	
Grade of mask ventilation	preparalysis	postparalysis
Grade 1	89	92
Grade 2	8	8
Grade 3	3	0
Grade 4	0	0

Table 6 summarizes the results of preoperative airway predictors with grade of mask ventilation both pre and post paralysis.

Table 5: Grade of mask ventilation preparalysis and postparalysis.

	Grade of mask ventilation preparalysis (p value)	Grade of mask ventilation postparalysis (p value)
Body mass index	0.061	0.078
age	0.011	0.014
Interincisor gap	0.007	0.0003
Neck circumferance	0.02	0.002
Thyromental distance	0.064	0.238
Sternomental distance	0.01	0.009
Ratio of height to thyomental distance	0.414	0.009
Mallampatti class	0.800	0.326
Best oropharyngeal view	0.361	0.197

Table 6: Pre and postparalysis factors affecting Grades of mask ventilation.

allow proper assessment as compared to best oropharyngeal view (BOV) which could be studied in 96 patients. Four patients all aged between 1-2 years, didn't allow assessment of BOV.

Assessment of bag and mask ventilation

The mask ventilation was assessed and graded both during preparalysis and post paralysis stage. In our study the incidence of difficult mask ventilation (Grade 3 and 4) was 3%. Grade of mask ventilation in our study changed post paralysis to a lesser difficulty level (Table 5). This change was statistically significant (Pearson Chi-Square - p value 0.000)

In our study, 82 patients allowed us to assess MMP class. Our study did not find a significant statistical correlation between grade of mask ventilation and MMP.

As compared to MMP assessment, 96 children out of 100 allowed us to assess best oropharyngeal view. Those who didn't allow were all less than two years. No statistical significant correlation was found between grade of mask ventilation and best oropharyngeal view using chi square test.

As shown in table 6, statistically significant correlation was found between grade of mask ventilation and age, interincisor gap, neck circumference and stern mental distance.

1) **Age:** During preparalysis period, only one case of grade II mask ventilation was seen in age group >3 years which changed to grade I postparalysis. This is in contrast to 28.6% and 18.8% children showing grade II/III grade of mask ventilation (GMV) in 1-2 years and 2-3 years age groups respectively in preparalysis phase. Although postparalysis the numbers of II/III GMV decreased slightly, they were still high as compared to 3-5 years age groups. Chi square test shows a statistically significant correlation between GMV and age [p value=0.011 (preparalysis)/0.014 (post paralysis)].

2) **Interincisor gap (IIG):** 94 patients out of 100 allowed the investigator to measure the IIG. The six patients who did not allow measurement of IIG were all less than 2 years age. The present study found a statistically significant correlation between IIG and GMV (pre-paralysis p value=.007, r=-0.27, power 75%; post paralysis p value=.0003, r =-0.37, power 96%).

3) **Neck circumference (NC):** Statistically significant correlation was found between NC and GMV (preparalysis p value=.02, r=-0.23, power 63%; post paralysis p value=.002, r=-0.31, power 88%).

4) **Steromental distance (SMD):** We have found a statistically correlation between SMD and GMV (preparalysis p value=0.01, r=-0.25, power 70%; post paralysis p value=.009, r=-0.26, power 71%).

Assessment of laryngoscopy and intubation

Cormack and Lehane grading (CL): In our study the incidence of CL grade 2 was 32%, CL Grade 3 was 3% and CL grade IV 0%.

Intubation difficulty score (IDS): 58% of cases had no intubation difficulty (IDS=0), 40% showed mild difficulty (0<IDS>5) and 2% showed major difficulty (IDS>5).

As shown in table 7, Age, TMD, BOV show a statistically significant correlation with both CLG and IDS.

Age: Our study suggests a statistically significant correlation between age and CLG (p value=0.017) between the age and IDS (p value=0.006, r=-0.35, power=95%). Results show that as the age increases percentage of cases with CLG grade 1 increases and percentage of cases with CLG grade II/III decreases.

Best oropharyngeal view (BOV): There was a statistically significant correlation between BOV and CLG (p value=0.008) between the BOV and IDS (p value=0.002, r=0.33).

Thyromental distance (TMD): 97 patients out of 100 in our study group allowed assessment of TMD. Minimum value of 3 cm and max value of 10 cm with mean of 5.1cm and S.D 0.93 were recorded. TMD shows statistically significant correlation with CLG (p value=0.012) and IDS (p value=0.001, r=-0.345, power=82%). Pearson correlation was also found taking IDS and TMD as continuous variables. A negative

	Cormack and lehane grade P VALUE	Intubation difficulty score P VALUE
Bodymass index	0.964	.027
Age	0.017	0.014
Interinscisor gap	0.078	0.095
Neck circumferance	0.028	0.739
Thyromental distance	0.064	0.238
Sternomental distance	0.077	0.038
Ratio of height to thyromental distance	0.059	0.022
MMP	0.192	0.005
Best oropharyngeal view	0.008	0.002

Table 7: Summarizes the results of preoperative airway predictors with Cormak and lehane grade (CLG) of laryngoscopy and Intubation difficulty score(IDS).

correlation (-0.345) was found i.e. as the TMD increases IDS decreases and vice versa.

Discussion

Difficult mask ventilation

In our study the incidence of difficult mask ventilation (Grades 3 and 4) was 3%. Unfortunately, no literature is available regarding incidence or prevalence difficult airway in pediatric population. Although many researchers have predicted incidence of difficult mask ventilation (DMV) in adult population as 1.4% - 5% (Kheterpal et al in 2006 and Langeron et al in 2000) [7,9] and impossible mask ventilation as 0.15%-0.16% (Kheterpal et al in 2006 and 2009) [7,10] But patients with anticipated difficult airways are frequently planned for awake intubation and are hence not subjected to mask ventilation. This changes the incidence of DMV by excluding the probable difficult cases [9] also, excluding the syndromic children could be the cause of lower incidence in our study. As the incidence of difficult mask ventilation is low, a larger sample size will be required to assess the relation, if any, of these factors with difficult mask ventilation. Further multicenter research is necessary in order to confirm are observed incidence.

Previous studies suggested that use of muscle relaxant does not alter the grade of mask ventilation [9,11]. However in our study grade of mask ventilation changed post paralysis to a lesser difficulty level. We did inhalational induction in children as compared to intravenous induction in the previous studies in adults. It's not clear whether this different induction method contributed to the change in grade of mask ventilation.

In our study, only one case of grade II mask ventilation was seen in age group >3 years This is in contrast to 28.6% and 18.8% children showing grade II/III grades of MV in 1-2years and 2-3years age groups respectively. Chi square test shows a statistically significant relation between grades of mask ventilation (GMV) and age. It suggests that as the age increases the difficulty in mask ventilation decreases. There are no studies in pediatric population to validate these findings.

96 children out of 100 allowed us to assess Best oropharyngeal view (BOV). Those who didn't allow were all less than two years. No statistical significant correlation was found between Grade of mask ventilation (GMV) and BOV using chi square test.

In our study 82 patients allowed us to assess mallampatti class (MMP). Studies in adults have found class III/IV to be a predictor of difficult mask ventilation (DMV). However, a meta-analysis done by Anna Lee et al found Mallampatti test poor at identifying DMV in adult population [12]. Our study did not find a significant statistical correlation between grade of mask ventilation and MMP .

In adult's body mass index (BMI) ≥26 and BMI ≥30 was found to be a predictor of DMV by Langeron et al in 2000 and Kheterpal et al in 2006 respectively. No statistical significant correlation was found between grade of mask ventilation and BMI using chi square test. Obesity is not common in Indian children less than 5 years, hence a larger sample size will be required to assess the relation of this parameter with difficult mask ventilation before we reach a conclusion.

In the present study 94 patients out of 100 allowed the investigator to measure the interincisor gap (IIG). The six patients who did not allow measurement of IIG were all less than 2 years age. The present study found a statistically significant correlation between IIG and grade of mask ventilation. This is in contrast to the previous studies which have not found to be a significant predictor in adults [7,9,10]. To the best of our knowledge, the existing literature is silent about this correlation in children.

Thick/obese neck had been found to be a predictor of DMV in study by Kheterpal in 2006 but no discrete value had been found for the same. We also found statistically significant correlation between Neck circumference and GMV.

No statistically significant correlation between thyromental distance and GMV was found in present study. Previous literature in adults suggests thyromental distance of less than 6 cm were independent predictors for grade 4 MV.

We have found a statistically significant correlation between sternomental distance and GMV. No study has been done in pediatric population or even in adults previously regarding the same.

There was no statistically significant correlation noted between ratio of height to thyromental distance (RHTMD) and GMV in our study. Literature is also silent as no study has been done in pediatric population or even in adults to find the relation between RHTDM and GMV.

Difficult laryngoscopy and intubation

In our study the incidence of CL Grade 3 was 3% and CL grade IV 0% and difficult intubation (IDS >5) came out to be 2%. In adult's researchers found difficult laryngoscopy and difficult tracheal intubation in 1.5% to 8% of general anesthetics [12-14]. Higher incidence of difficult laryngoscopy is more common in patients with cervical disease, diabetics, acromegaly and obesity. Heterogeneity in incidence can be because of large number of confounding factors like age, BMI, interobserver variation, sample size, coexisting diseases in studied population etc.

Our study suggests age as predictor of difficult laryngoscopy and intubation. As age increases laryngoscopy and intubation becomes easier. Pediatric airway is grossly different from adults. They have proportionately large head, larynx is situated more cephalad, tongue occupies a proportionately large part of oral cavity, epiglottis is large and floppy and difficult to lift using conventional laryngoscopic technique etc. These changes tend to diminish as the child grows and after 2 years of age airway is more or less similar to adult apart from small in size. This explains the above result that securing a definitive airway will become easier with age. Literature search did not suggest age as a predictor of difficult laryngoscopy or intubation in adults. Studies in pediatric population are lacking.

Our study suggests a statistically significant correlation between best oropharyngeal view (BOV) and Cormack and lehane (CLG) (p value=.008) between the age and IDS (p value=.002). Further studies will be required to confirm its usefulness.

Our study suggests that children less than 3 years are not cooperative enough to allow assessment of MMP class. MMP class is not a predictor of difficult laryngoscopy and intubation. Since children less than 3 years have potentially more difficult airway as compared to their older counterparts and this was predominantly the age group which did not allow MMP assessment. Hence, results of the correlation between MMP and CLG, MMP and intubation difficulty score (IDS) could be false or coincidental and study with larger sample size will be required. Although in adults, MMP has good accuracy in predicting difficult laryngoscopy or intubation [12]. Only one study on the same was available which showed a good correlation between Mallampatti class and Cormack and lehane grade between ages 4-8 years [15].

As previously hypothesized, best oropharyngeal view (BOV) could be assessed in majority of children; results show BOV as predictor of difficult laryngoscopy and intubation. This parameter has never been used in past as a predictor of difficult airway. Further studies may confirm it as a useful predictor in pediatric population.

Our study does not found BMI as predictor of difficult laryngoscopy and intubation. Review of literature showed some studies did not demonstrate obesity as an independent risk of difficult laryngoscopy and difficult tracheal intubation (DTI), but others seemed to show that obese patients are at risk of DTI. These studies may have failed to detect or reject obesity as a risk factor for DTI due to small patient numbers and subsequent lack of power. These studies excluded patients aged less than 15 years from their study [13,16].

Interincisor gap seemed in our analysis to be an inadequate predictor of difficult intubation. Studies in adults also didn't found IIG as predictor of difficult laryngoscopy [17,18].

Neck circumference was not found to be good predictor of difficult laryngoscopy and intubation. Gonzalez H found increasing neck circumference associated with problematic intubation in adults. No absolute values are given in literature either for adults or for pediatric age group.

The diagnostic value of thyromental distance proved satisfactory in our analysis. A negative correlation was found i.e. as the TMD increases IDS decreases and vice versa. In adult, role of TMD as predictor of laryngoscopy with intubation is not clear. Some found TMD <6 cm is a predictor of difficult laryngoscopy with intubation [14] and others disapprove this fact [17]. Heterogeneity of results could be could be due to variation in age group and interobserver variability. A discrete value of 6 or 6.5 cm as in adults may not be a possibility in children because of their growing body dimension.

Our study diagnostic performance of sternomental distance (SMD) and ratio of thyromental distance is inconclusive, though studies in adults found them to be a sensitive predictor [18,19]. The negative likelihood ratio of SMD was lower than that of any other test, suggesting that it is the best single test for ruling out difficult intubation in adults.

Our results are affected by several important limitations. As the incidence of difficult airway in pediatric population is not known the sample size for power to be 80% couldn't be found at start of this study. Sample size if we compare with similar studies in adults is small to conclusively state the results of our study population can be applicable for entire pediatric population and further studies with larger sample size will be required. As pediatric airway dimensions change with growing age finding absolute figures of thyromental distance, sternomental distance, interincisor gap etc below which airway can be judged difficult as given for adults is not possible. But in pediatric population distances can be given in multiples of finger diameter.

Despite these limitations our study offers valuable insight into concerning clinical event that is difficult to study and has never been studied in this population. We also predict a new parameter Best Oropharyngeal View (BOV) grading as a more practical parameter of airway assessment in pediatric population compared to MMP classification.

Conclusion

In conclusion, we would like to suggest that age, interincisor gap, neck circumference and sternomental distance are predictors of difficult mask ventilation. Age, best oropharyngeal view and thyromental distance are predictors of difficult laryngoscopy with intubation. Also, mask ventilation became easier post paralysis. Best oropharyngeal view is a better airway assessment tool than MMP classification.

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