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Comparison of two ultrasonographic approaches of airway assessment (transcutaneous versus sublingual) for prediction of difficult laryngoscopy

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Abstract

Background and aims: Difficult intubation cannot always be predicted based on pre-operative airway assessment using conventional clinical predictors. Ultrasonography has been extensively used for Airway assessment. All the studies till date have used the trans cutaneous approach except for one recent pilot study which used the sublingual approach claiming that it was accurate and better. So, we conducted a randomized double-blind observational study comparing these two approaches to see which was a better predictor of difficult intubation.

Methods: Hundred ASA grade I-II patients undergoing elective urological surgery were selected for the study. In the pre-operative room sonographic assessment of the airway was done. In the trans cutaneous approach the hyo-mental distance was measured while the head was placed in supine and then in hyper extended position and the ratio of the two distances (HMDR) was calculated. HMDR of less than 1.1 predicted difficult intubation. In sublingual approach the probe was put in the sublingual region and the inability to visualize the hyoid bone on sonography predicted difficult intubation. So, with both the approaches we tried to assess whether the hyoid bone was caudally or rostrally placed. The patients were then taken in the operation theatre where an experienced anesthesiologist blinded to the results of airway evaluation by sonography performed direct laryngoscopy

and graded the views using Cormack lehane's classification with grade 3 and 4 as difficult intubation

Results: The incidence of difficult intubation in our study was 14%. The sublingual approach had a sensitivity and specificity of 42 and 83.7% respectively in predicting difficult intubation.

With transcutaneous approach the sensitivity and specificity were 57% and 82.5% respectively. Positive predictive value and negative predictive value were comparable in both the groups.

Conclusion: Our study suggests that though sublingual approach is feasible and technically easier the transcutaneous approach is more sensitive and has a higher predictive value (AUC=2.84). We demonstrated that a value of less than 1.1 can be used as a test threshold that is a value of less than 1.1 predicts difficult laryngoscopy with a sensitivity of 57% an accuracy of 82.5%.

Keywords: Sublingual ultrasonography, Hyoid bone, Hy omental distance ratio, Cormack Lehane classification.

Introduction

Difficult airway is a nightmare for anesthesiologist. Failure to predict and prepare for the difficult airway has obvious implications for morbidity and mortality, the more severe being unrecognized esophageal intubation, aspiration, neurological impairment and hypoxic cardiac arrest [(1)]

Successful airway management requires knowledge and a range of skill sets specifically, the ability to predict difficult airway and to formulate an airway management plan. Pre-operative physical airway assessment includes Mallam Patti grading, thyromental distance, at lento occipital joint extension etc. [(2)]. Despite widespread adoption of these predictors by anesthesia providers unexplained difficult intubation still continue to occur, reflecting their poor sensitivity and specificity [(10,4)]

Nowadays the ready availability of sonography machines in the anesthesia department has promoted its use for vascular access, regional nerve blocks and airway assessment [(5)]. Because of the high quality of imaging, non-invasiveness and relatively low-cost USG has been utilized as a valuable adjunct to the clinical assessment of the airway in the last two decades. Till date all the ultra-sonographic studies have used the transcutaneous approach with the exception of one recent pilot study, which use the sublingual/ intra oral approach claiming that it was efficient and better [(3,6,7,8)]. Therefore, we decided to do a randomized observational study comparing these two sonographic approaches of airway assessment.

Aims and objectives

To find if sublingual approach was feasible.

To compare the transcutaneous and sublingual approach of Ultra sonography in predicting difficult laryngoscopy.

Materials and methods

After obtaining approval from the ethical committee and written informed consent from the patient a prospective randomized double-blinded observational study was initiated. 100 adult patients of ASA grade I and II undergoing elective surgery requiring general anesthesia with direct laryngoscopy and endotracheal intubation were enrolled. The study was conducted in strict accordance with the principles of declaration of He Lenski.

Patients with anticipated/past history of difficulty intubation, prégnant patients, obese patients, patients with anatomical abnormality of the upper airway or fractures of the maxillofacial bones were excluded from the study. Pre-operatively the physical airway parameters were assessed. Prior to initiating this study ultrasonography of the airway was performed in 40 adult patients in the presence of an experienced radiologist in

order to get familiarized with the sonographic appearance of airway structures. In the pre-operative room, the ultrasound view of the airway of all enrolled patients was assessed by the same anesthesia consultant using Phillips Affinity 70 G ultrasound machine. The patients were explained about the procedure in detail. For the sublingual approach, the patients were in sitting position. The patient was asked to open his /her mouth and touch the hard palate with the tip of his tongue. We then took the pediatric ultrasound probe C 8-5 (5-8 MHz), covered it with a sterile cover and placed it longitudinally under the tongue. Then the probe was advanced straight back as far as was comfortable for the patient. Hyoid bone on USG appeared as superficial, hyper echoic, inverted U-shaped linear structure with posterior acoustic shadowing. For the transcutaneous approach, the patient was in supine position with head in neutral position without pillow, looking straight ahead with the mouth closed and tongue on the floor of the mouth. High-frequency curved probe (12-5 am Hz) was placed on the skin, under the patient's chin to get a mid-sagittal view. The mentum and hyoid bone appear in mid sagittal scan as hyper echoic structures with hypoechoic shadowing. The Hy omental distance in neutral position was measured. The patients were then instructed to extend their necks maximally while taking care to avoid lifting their shoulders off the table and the Hy omental distance in extended position was measured from the upper border of the hyoid bone to the lower border of the mentum. Then the Hy omental distance ratio (HMDR) was calculated.

$$\text{Calculated HMDR} = \frac{\text{HMD in extended position}}{\text{HMD in neutral position}}$$

All the patients were then taken to the operating room and standard monitors like ECG, NIBP, pulse oximetry were attached and intravenous line was secured. Balanced general anesthesia was given to all patients. Direct laryngoscopy in all study cases was performed by a senior anesthesiologist (unaware of the findings of ultrasonography) who was then asked to state the Cormack and Lehane grading for the vocal cords view (grade 1 to 4) without external laryngeal manipulation. All the laryngoscopies were performed with the patient placed in sniffing position using number 4 Macintosh blade. The laryngoscopy was classified as easy (CL grade 1-2) or difficulté (CL grade 3-4). The airway was secured with the cuffed endotracheal tube and the patients were maintained on infusion of muscle relaxant, air, oxygen and inhalation agent.

Statistical analysis

The data was entered in Microsoft Excel 2010 and analyzed with Epi info version 7.1. Continuous data was presented with mean +_ SD while categorical data was presented with frequency and percentage. According to CL grade patients were categorized into two groups-easy intubation and difficult intubation. The continuous data between two groups were compared using Z test and categorical data was analyzed with chi-square test. P value less than .05 was considered as significant

The sensitivity, specificity, positive predictive value, negative predictive value and accuracy were calculated for hyoid Bone visualisation on ultra-Sound, TMD and HDMR to predict difficult intubation. Receiver operating characteristics (ROC) curves for predicting difficult intubation were plotted for TMD, HDMR. Predictive accuracy was measured by area under the curve (AUC) with 95% confidence interval.

Sample size calculation

Pilot study was conducted among 30 patients. Out of them 2 patients had difficult intubation so proportion of difficult intubation was 6.6% (2/30).

Sample size = $Z(1-\alpha/2)\ 2\ P(1-p)/d2$

Z 1-α/2= Is standard normal variate (at 5% type 1 error, it is 1.96)

p = expected proportion of difficult intubation – 6.6% = 0.066

q = 1-p = 1-0.066 = 0.934

d = absolute error or precision = 5% = 0.05

N = $Z(1-\alpha/2)$ 2 p q /d 2

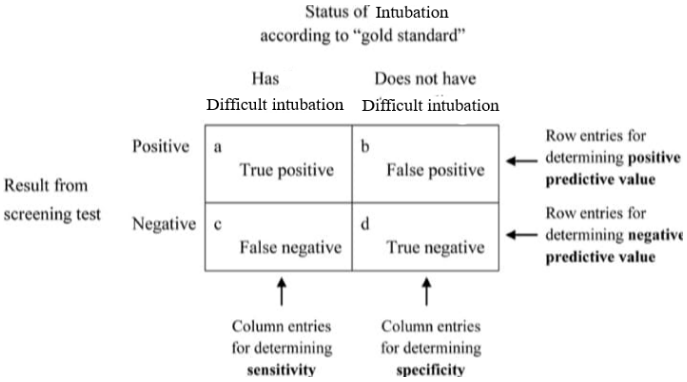
N = 1.962 × 0.066 × 0.934 /(0.05) 2

N= 94.7-95

Sample size was further inflated by 5% to take care of refusals.

Final sample size is 95 +5 (5% of non-response) =100

Distribution of diagnostic statistics used in the study



Observations and results

100 patients were enrolled in the study as per demographic characters depicted [Table-1]

Table 1: Socio demographic characteristics of patients.

Characteristics	
Age (Means ± SD)	46.76 ± 14.49
Gender	No of cases (%)
Male Female	70(70%) 30(30%)
Male: female ratio	2.3:1

Paediatric ultrasound probe was placed correctly in the floor of the mouth of patients for visualization of the hyoid bone. Ultrasound examination took less than one minute in all patients and no adverse effects were reported.

A senior anesthesiologist senior performed laryngoscopy in all patients. The Cormack Lehane grading system was used to describe the laryngeal view during laryngoscopy. [Table-2]

Table 2: Ease of intubation according to Cormack Lehane grade: (gold standard)

Cl grade	NO. OF CASES(n=100)
Grade 1&2 (easy)	86
Grade 3&4 (difficult)	14

Table 3: Ease of Intubation According to USG Parameters

Usg parameters	No. Of cases(n=100)
Sublingual approach	
Hyoid bone seen (easy)	80
Hyoid bone not seen(difficult)	20
Transcutaneous approach	
Hmdr (Hy omental distance ratio)	
>1.1	78
<1.1	22

Table 4: Ability of airway assessment methods to predict the grade of laryngoscope view

Assessment methods		CL Grading	Total	P value
	DI (n=14)	EI (n=86)		
		Hyoid bone		
Not seen (Difficult)	6(42.9%)	14(16.3%)	20(20%)	X 2=5.31 P=0.02
Seen (Easy)	8(57.1%)	72(83.7%)	80(80%)	
		HMDr		
< 1.1	8(57.1%)	15(17.4%)	23(23%)	0.009
> 1.1	6(42.1%)	71(82.5%)	77(77%)	
Total	14(100%)	86(100%)	100(100%)	

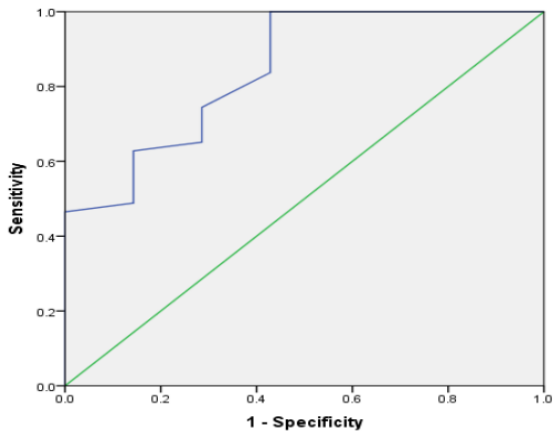
Table 5: Comparison between accuracy of the various parameters to predict difficult laryngoscopy

Parameter	Sn	Sp	PPV	NPV	Accuracy
TMD (< 6 cm)	78.5	61.6	25	94.6	64.0
Hyoid bone (Not seen) (SUBLINGUAL APPROACH)	42.9	83.7	30	90.0	78.0
HMDR (<1.10) (TRANSCUTANEOUS APPROACH)	57.1	82.5	34.7	94.5	71.8

Roc curves: (receiver operating characteristics)

The ROC curve is a graphical display of sensitivity and specificity and the Area under curve (AUC) is an effective measurement for assessing the inherent validity of the test. The maximum AUC indicates a perfect diagnostic test. The AUC for HMDR transcutaneous approach was 0.84 indicating that it has a high validity. We could not calculate the AUC for sublingual approach as it was a qualitative data (hyoid bone seen/not seen). **[**Figure-1**]**

Figure 1: ROC curve of HMD for predicting difficult intubation.



Discussion

The reported incidence of difficult laryngoscopy or endotracheal intubation varies from 1.5 to 13% in patients undergoing surgery [(9)]. The incidence of difficult laryngoscopy in our study was 14%. (14/100). Recognizing before anesthesia the potential for difficult airway allows time for optimal preparation, proper selection of equipment and technique and participation of personnel experienced in difficult airway management. There are many non-invasive screening tests for airway assessment but they do not necessarily correlate with CL grading during direct laryngoscopy [(10,4)]. Cormack Lehane classification is considered to be the gold standard for predicting difficult intubation, however the major drawback is that it is too invasive a technique to be used in awake patients preoperatively. Therefore, a non-invasive screening test to predict difficult intubation with greater accuracy is the need of the hour. USG has been extensively used for prediction of difficult airway in the last few years. All the studies mentioned have used the transcutaneous approach for USG guided measurements where the probe is placed in transverse/ sagittal plane in the submandibular space except for the study by Tsui and Hui et al where an intra oral / sublingual approach was used for the first time. The authors claimed that sublingual probe placement was efficient, provided excellent issue contact which resulted in stable images while avoiding contact with soft palate thereby circumventing an unpleasant gag reflex [(3)]. This was an advantage over trans cutaneous approach where we encounter difficulty in maintaining a good skin contact over the uneven and curved surface of the anterior neck. Therefore, we decided to conduct a study to determine the feasibility of sublingual approach for examination of the airway We wanted to see if correlation existed between USG visualization of hyoid bone and CL

grading during laryngoscopy. We also compared the two approaches (sub lingual vs transcutaneous) in predicting difficult laryngoscopy. [Table-3]

Importance of Hy omental distance in airway assessment

Difficult intubation is attributed to several unfavorable anatomical factors such as receding mandible, protruding upper incisors, long maxilla, limited mobility of temporomandibular joint, caudally placed hyoid bone and decreased pharyngeal space. All these factors can be appreciated on physical examination except for the hyoid bone which is many a times difficult to palpate. Therefore, we choose a parameter which included hyoid bone in sono Graphy measuements by both the approaches.

Because the tongue muscles are hinged to the hyoid bone if the hyoid is caudally placed a large portion of tongue will be in the hypopharynx instead of the oral cavity, which makes it difficult to align the oral pharyngeal laryngeal axis, making intubation difficulté. [Table-4]

In our study with both the approaches we tried to assess whether the hyoid bone was placed rostrally or caudally and which approach was better in predicting difficult laryngoscopy.

Regarding the sublingual approach we observed that all the patients cooperated well and it was easy to perform showing that this approach is feasible, simple and well tolerated for pre-operative airway assessment [(3)]. In this approach if the hyoid bone is placed caudally (i.e., increased hyo mental distance) then it is less likely to fall in the field of view of ultrasound probe and is not visualized on USG, predicting difficult laryngoscopy. In our study sublingual ultrasonographic visualization of hyoid bone had a sensitivity of 42.9% and positive predictive value of 30% for predicting difficult intubation as determined by laryngoscopy. [Table-5] The above findings are in contrast to the observation of Tsui and Hui et al where they noted that the sublingual approach had a sensitivity of 70% and positive predictive value of 21% [(3)]. The difference could be because of the difference in ethnicity of the population studied (American vs Asians). The lower sensitivity of sublingual approach could be due to the fact that it does not evaluate other airway factors like tongue shape and size, restricted neck movements etc. which might cause difficult intubation. In patients with difficult intubation, it has been shown that during direct laryngoscopy a large tongue can impede the glottic view and lead to a poor laryngoscopy grade. Tongue size may have a greater impact on direct laryngoscopy as the blade is placed on the top of the tongue during airway evaluation while sublingual sonography involves placing the probe under the tongue. Perhaps the simultaneous measurement and examination of tongue during sublingual ultrasound will help us to overcome this drawback and enhance airway assessment.

In the trans cutaneous approach we measured the Hy omental distance in extreme extension of head and in neutral position and calculated the hyomental distance ratio. (HDMR = HMD e/ HMD n) because Hy omental distance alone has only a modest degree of diagnostic accuracy [(11)]. Take Naka et al has concluded in his previous study that HDMR correlated with occipital at Lan to joint extension capacity and was a good predictor of difficult intubation. (23) Rana et al went a step further and measured HDMR sonographic ally and observed that HDMR less than 1.2 predicted difficult intubation [(13)]. In our study HDMR had a sensitivity of 57% for predicting difficult laryngoscopy which was significantly higher than that of sublingual approach. Sensitivity is important for an ideal screening test. Sensitivity of the test in the present study is the power of the test to find out the maximum number of difficult laryngoscopies. The

sensitivity of HDMR in study done by Rana et al was 75%. However, HDMR has a low positive predictive value of 29% which is similar to findings of Jin Hui et al (23%) [13,14]. The high false prediction based on this test may subject many patients to unnecessary procedures but we believe that minimizing false negative predictors with HDMR is preferable to minimizing false positive because higher number of false negative predictors may lead to potentially serious scenario of failed intubation.

In our study; the range of HDMR was 1.18±1 and 1.08±06 in easy and difficult intubation groups respectively which is similar to findings of Rana et al [13]. In the study of Wojtczak et al the authors observed that HDMR in the difficult intubation group was in the range of 1-1.05 and in the easy intubation group was in the range of 1.12 - 1.16[11]. The difference between the mean HDMR values in these two studies could be attributed to the difference in the profile of patients, as obese patients were recruited in the study of Wojtczak et al while all our patients were with a BMI < 30 kg/ m2. The cut-off value for HDMR in our study for predicting easy and difficult intubation was 1.1 while it was 1.2 in the study of Wojtczak et al.

The diagnostic accuracy of HDMR was assessed by calculation of the area under curve (AUC) for ROC curve with 95% confidence interval. The area under curve for HDMR was 0.84 which is closest to 1 indicating that HDMR has the highest validity studied with an optimal cut-off point at 1.1 with a sensitivity of 57% and specificity of 71% for predicting difficult laryngoscopy

Limitations of our study

We did not include patients with BMI more than 30kg/m2. Further studies can be done involving patient group having factors associated with difficult intubation. When using sublingual approach our patients were in sitting neutral position. Despite some controversy over its merits sniffing position is regarded as the optimal starting position for airway assessment. The sitting neutral position was chosen to make the USG scanning procedure more standardized. However, this might have resulted in sub optimal alignment of the airway axis.

Difficult laryngoscopy does not necessarily correlate the difficult intubation as external laryngeal manipulation tends to facilitate intubation most of the time.

A single indicator has poor predictive power when utilized alone. Rather than using HDMR or visualization of hyoid bone alone, we have to find a combination of USG parameters which can provide a high index of sensitivity and specificity for predicting difficult laryngoscopy

Conclusion

Our study results suggest that though sublingual approach is feasible and technically easier, the transcutaneous approach is more sensitive and has a higher predictive value (AUC =0 .84). We demonstrated that the value of less than 1.1 can be used as a test threshold a value of less than 1.1 predicts difficult laryngoscopy with a sensitivity of 57% and accuracy of 79.1%

But none of these tests alone have provided 100% prediction of difficult laryngoscopy. Therefore, we recommend seeking an optimal combination of tests that include HDMR or ultra-sonographic visualization of Hyoid bone and other ultra-sonographic predictors and performing the tests in combination for prediction of difficult airway, rather than using them separately.

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