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ULTRASOUND MEASUREMENT OF LARYNGEAL STRUCTURES IN THE PARASAGITTAL PLANE FOR THE PREDICTION OF DIFFICULT LARYNGOSCOPY

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Abstract

Introduction: Airway management is one of the major concerns for all anaesthesiologists. Failure in securing the airway increases the morbidity and mortality of patients undergoing surgery under general anaesthesia. Patients undergoing cardiac surgical procedures have higher incidence of difficult laryngoscopy than other patients because of the associated risk factors. It is estimated to be 10%. Ultrasound in addition to other standard methods increased the predictability of difficult airway and is non-invasive, inexpensive and reliable. The visualization of skin, epiglottis and thyroid in the parasagittal plane using ultrasonography has shown promising results in identifying difficult airway.

Materials and methods: A prospective observational study was conducted over a period of 5 months. Institutional ethical committee clearance and Informed consent were taken prior to the study. Sequential sampling of 284 patients posted for elective cardiac surgery between age group 18-64 years was done. These patients satisfied the inclusion and exclusion criteria. They underwent pre-operative investigations as per institutional protocol. Airway examination which included Modified Mallampati Test (MMS), cervical mobility, Thyromental distance (TMD) and inter-incisor distance were assessed and recorded preoperatively. On the day of surgery standard ASA monitors were attached to the patients. Ultrasonography (US) of the airway in the parasagittal plane was performed and distance between skin-epiglottis(US-DSE), skin-thyroid(US-DST), thyroid-epiglottis(US-DTE) were recorded. The patients were induced as per the institutional protocol and laryngoscopy was performed by an experienced anaesthesiologist. Cormack Lehane grading(CL grade) was noted and patients were intubated with appropriate sized endotracheal tube (ETT).

Results: Among 284 patients examined, 211 patients were easy intubation with CL grade 1 or 2. 73 patients had CL grade 2B or 3A. No patients were excluded from the study. In the study US-DSE, US-DSE and US-DTE obtained in parasagittal plane were found to be statistically significant in predicting the difficult airway. MMS along with US-DSE was found to be statistically significant and a better predictor of difficult airway when compared with other existing methods of predicting difficult airway.

Conclusion: Cardiac patients are more prone for difficult intubation due to co-existing diseases. Ultrasonography of airway in parasagittal plane as a method of screening has a significant role in predicting difficult airway anaesthesia. US-DSE has a high sensitivity, specificity, positive predictive value, negative predictive value and accuracy. When combined with MMS, US-DSE can be of great help in predicting difficult airway. Among the non-invasive parameters, MMS grading was closely related to the ultrasound parameters US-DSE, US-DTE and US-DST. Thus Ultrasonography in parasagittal plane has a ray of hope and can be used as an independent predictor in prediction of difficult airway.

Key Words: Airway management, Ultrasound, parasagittal plane, endotracheal tube.

INTRODUCTION

The management of the airway is the primary responsibility of anaesthesiologists. It includes maintaining airway patency, thereby ensuring adequate ventilation and oxygenation. Airway management is encountered by the anaesthesiologists during the conduct of anaesthesia or resuscitation of critically ill patients every day.

Traditionally, the airway is maintained by mask ventilation and tracheal intubation with endotracheal tube. In modern day practice, Supraglottic airway devices like laryngeal mask airway (LMA) play a crucial role in airway management. Endotracheal intubation remains the gold standard in maintaining definitive airway, in spite of many advances.

The endotracheal intubation is conventionally facilitated by direct laryngoscopy. The alternate methods include tracheal intubation using fibreoptic bronchoscope, video laryngoscopy, video endoscopy, intubating LMA and various other airway adjuncts.

However the cost and availability of these airway adjuncts, force the anaesthesiologists to use conventional laryngoscopes routinely. Hence, assessing the airway and predicting the difficulty in mask ventilation or intubation is of utmost importance.

Difficult Airway (DA) is defined as “the clinical situation in which a conventionally trained anaesthesiologists experiences difficulty in ventilation of upper airway via a mask, difficulty in tracheal intubation or both”.

Difficult Laryngoscopy (DL) is defined as a situation where “It is not possible to visualize any portion of the vocal cords after multiple attempts at conventional laryngoscopy”. Failed intubation occurs in 75% of difficult laryngoscopy (DL) cases and only in 3 % of Easy Laryngoscopy (EL) cases.

Failed or Difficult intubation may lead to a "Cannot intubate - Cannot ventilate" (CICV) Situation. CICV is a life threatening situation. Failure to ensure adequate oxygenation either by mask ventilation or intubation may lead to oxygen desaturation.

ASA closed claims study in 1990 revealed that the "adverse respiratory events" is the major contributor (34%) among the total claims related to anaesthesia. Death occurred in 85% of these cases.

The major causes were lack of adequate ventilation (38%), intubation into Oesophagus (18%) and difficult tracheal intubation (17%). Prior recognition of difficult airway may help to minimize the above adverse effects.

In an independent study on Chinese population, the visualization of skin-epiglottis distance, skin-thyroid distance and thyroid-epiglottis distance using ultrasound has shown promising results in identifying difficult airway5. My study is designed by taking into consideration the established validity of the known parameters and comparing them with the airway ultrasound in parasagittal plane to predict the difficult laryngoscopy in individuals posted for elective cardiac surgical procedures.

AIM

To test the sensitivity of the measurements obtained by focused airway ultrasound in parasagittal plane and compare its validity with existing standard airway indices in predicting difficult laryngoscopy (MMS, CL grading, neck extension, TMD).

OBJECTIVES

Primary outcome: To assess the sensitivity, specificity and predictive value of distance between skin and epiglottis in parasagittal plane using focused airway ultrasonography of the upper airway in predicting difficult airway.

Secondary outcome:

Compare ultra-sonography anatomy of upper airway in parasagittal plane with other existing methods of predicting difficult airway (MMS, CL grading, neck extension, TMD).

MATERIALS AND METHODS

The institutional ethics committee approval for the study and written informed consent from patients were obtained prior to the study.

STUDY SITE: The proposed study was conducted at a tertiary care centre in BENGALURU.

STUDY DESIGN: This is a prospective observational study

STUDY DURATION: The proposed study was performed over a period of 5 months from May 2021 to September 2021 after obtaining the institutional ethical committee clearance.

STUDY POPULATION:

INCLUSION CRITERIA

• Patients undergoing elective cardiac surgery under general anaesthesia

• ASA physical status 2, 3

• Patients aged 18-64 years of either sex

• No upper airway deformity, mandibular deformity, tumour or trauma

EXCLUSION CRITERIA:

• Modified anaesthesia protocol or cancellation of tracheal intubation

• Identified difficult airway or difficult airway history that requires patient to be awake during tracheal intubation.

SAMPLE SIZE: The objective of the study was to calculate sensitivity of the values obtained by ultrasonography. This was calculated based on the anticipated sensitivity of 0.82, specificity of 0.86 and prevalence of 0.2 from previous studies. The sample size was calculated using the below formula. Level of significance was kept at 5%. The values used for calculation are mentioned in the table below. A sample size of 284 was required.

METHODOLOGY

Patients between 18-64 years of age belonging to American Society of Anaesthesiologists (ASA) grade 2-3 of both sexes, undergoing elective cardiac surgery under general anaesthesia were included in the study.

Those patients who were not meeting inclusion criteria were excluded from the study as mentioned above. Written informed consent was taken from all the recruited patients.

The person performing the airway ultrasound and laryngoscopy were different. The results of ultrasound and laryngoscopy of patients were classified into 2 categories.

• Measurements in patients with difficult airway

• Measurements in patients without difficult airway.

The study was performed in three phases:

• The airway assessment was done pre- operatively.

• Ultrasonography of airway was done before induction of anaesthesia.

• Direct laryngoscopy was assessed intra- operatively.

Pre Anaesthetic Assessment:

The patients posted for elective cardiac surgery were investigated as per the departmental protocol. A detailed history, clinical examination and routine investigations including laboratory

test biochemical tests (renal function tests and liver function tests), haematological tests (haemoglobin, total count, differential count, platelet count), Chest x-ray (PA view) & 12 lead Electrocardiograph were assessed in the pre-anaesthetic assessment clinic. The patients on arrival to the operating theatre complex were reviewed prior to shifting inside the operation theatre.

Airway assessment:

All patients underwent airway examination prior to surgery during which Modified Mallampati test (MMS), Thyromental distance (TMD), inter incisor distance (IID), cervical mobility were assessed by an anaesthesiologist and recorded in the proforma. Furthermore age, sex, height, body weight and body mass index of all patients were recorded. Name of the patient was not included in the study.

PREPARATION:

Premedication was given the night before surgery-

1. Tab Pantoprazole 40 mg.

2. Tab Alprazolam 0.25 mg.

Induction with General Anaesthesia was followed after initial airway assessment with ultrasonography. In patients with anticipated difficult airway, the difficult airway algorithm was followed and difficult airway cart with required equipment's was kept ready.

Since all were cardiac cases, a standard institutional protocol was followed. Patients were pre-oxygenated with 100%oxygen for 3 minutes. Induction was done with intravenous midazolam 1mg, fentanyl 5mcq/kg, etomidate 0.2mg/kg. After check ventilation, muscle relaxant rocuronium 1.2mg/kg was given. Patients were manually ventilated followed by direct laryngoscopy. The patient's head was placed in sniffing position and laryngoscopy was done using Macintosh blade size 3 or size 4 by an experienced anaesthesiologist (minimum 2 years of experience post-graduation). Cormack Lehane's grading was recorded.

Cormack Lehane grades 1 and 2A were considered as "Easy visualization of larynx (EVL)" and grades 2B, 3, and 4 as "Difficult visualization of larynx (DVL)".

Patients were intubated with appropriate sized cuffed oral endotracheal tube (ETT), secured after confirming bilateral air entry. The ETT was connected to the ventilator and anaesthesia was maintained with inhalational agents.

The preoperative assessment data and laryngoscopy findings were used together to evaluate the accuracy of ultrasonography in predicting difficult laryngoscopy. The sensitivity, specificity, positive and negative predictive values and accuracy of each test calculated according to standard formula.

This study took into consideration only the CL grading and the use of bougie, McCoy or other manoeuvres to secure the airway were not included as a part of the study.

STATISTICAL METHODS: All data required for the study were collected and tabulated in Microsoft Excel sheet. The Qualitative data obtained were represented in the form of frequency and percentage. Association between qualitative variables were later assessed by Chi Square test. Mean & Standard value was calculated for continuous variables. Mean between two groups were analysed by using Student's t test unpaired. To assess the accuracy, sensitivity, specificity, PPV, NPV, Diagnostic accuracy & ROC curve were plotted to test Area under the curve (AUC). Sensitivity, specificity ultrasound values, Modified Mallampati test, Thyromental distance, inter incisor distance and cervical mobility were noted. Kappa statistics was used to find the agreement between the two assessments. A P value of <0.05 was considered statistically significant. IBM SPSS Version 22 for Windows was used for statistical analyses of the data.

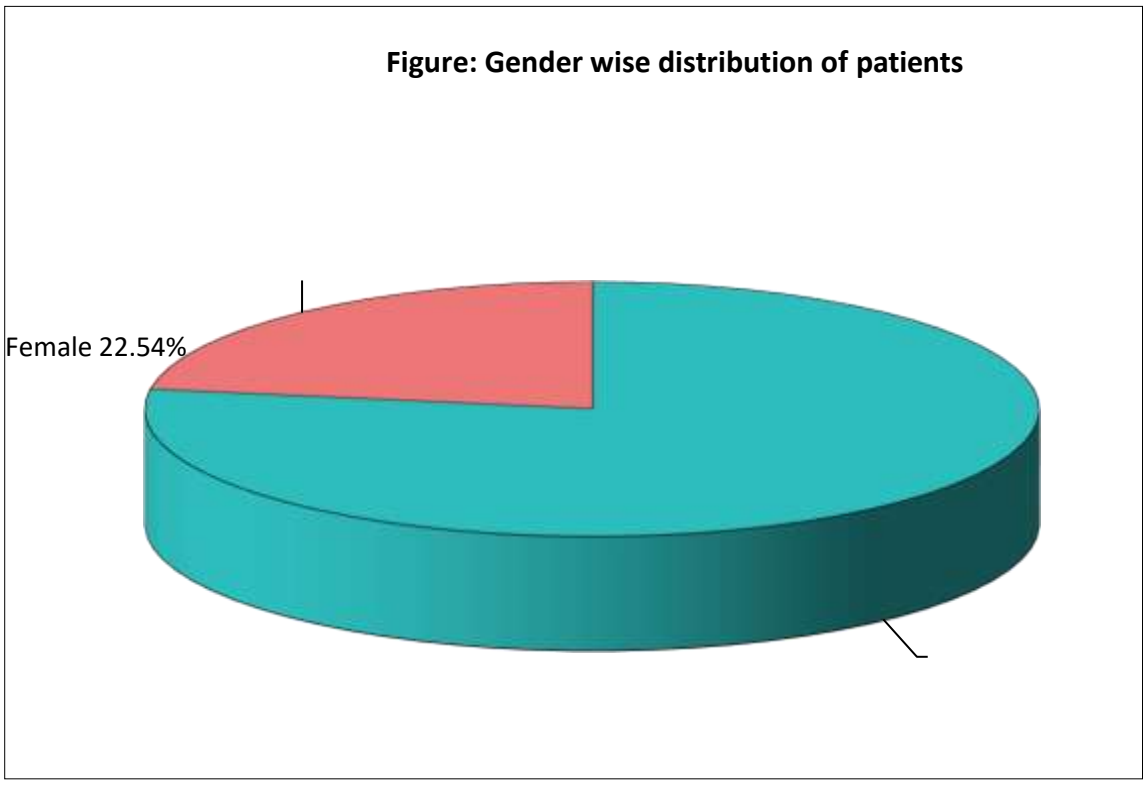
RESULTS

284 patients were enrolled in this prospective observational study after obtaining informed consent.

CASE STUDY PROFILES

TABLE 1: GENDER WISE DISTRIBUTION OF PATIENTS

Gender	No of patients	% of patients
Male	220	77.46
Female	64	22.54
Total	284	100.00

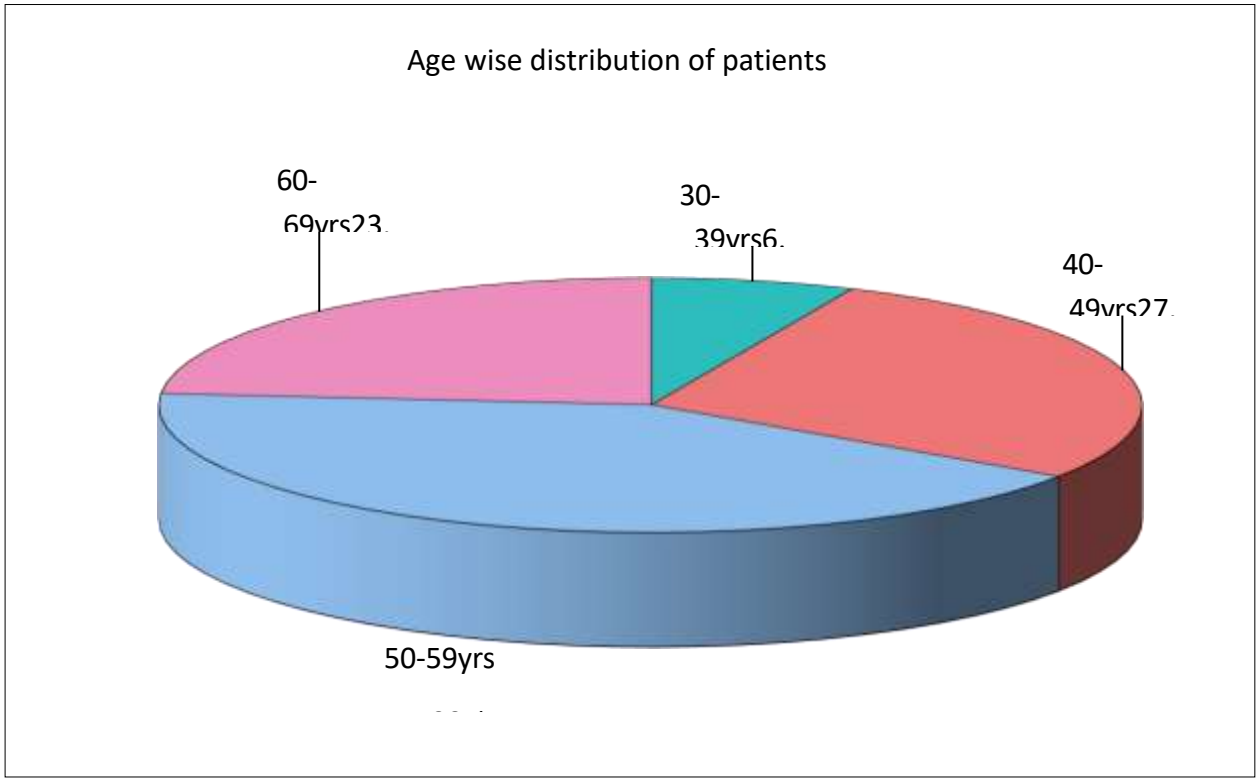


GRAPH 1-GENDER WISE DISTRIBUTION OF PATIENTS

Among 284 patients, 220 patients were male (77.46%) and 64 were female (22.54%).

TABLE 2: AGE WISE DISTRIBUTION OF PATIENTS

Age groups	No of patients	% of patients
30-39yrs	19	6.69
40-49yrs	79	27.82
50-59yrs	119	41.90
60-69yrs	67	23.59
Total	284	100.00
Mean	52.93	
SD	8.09	

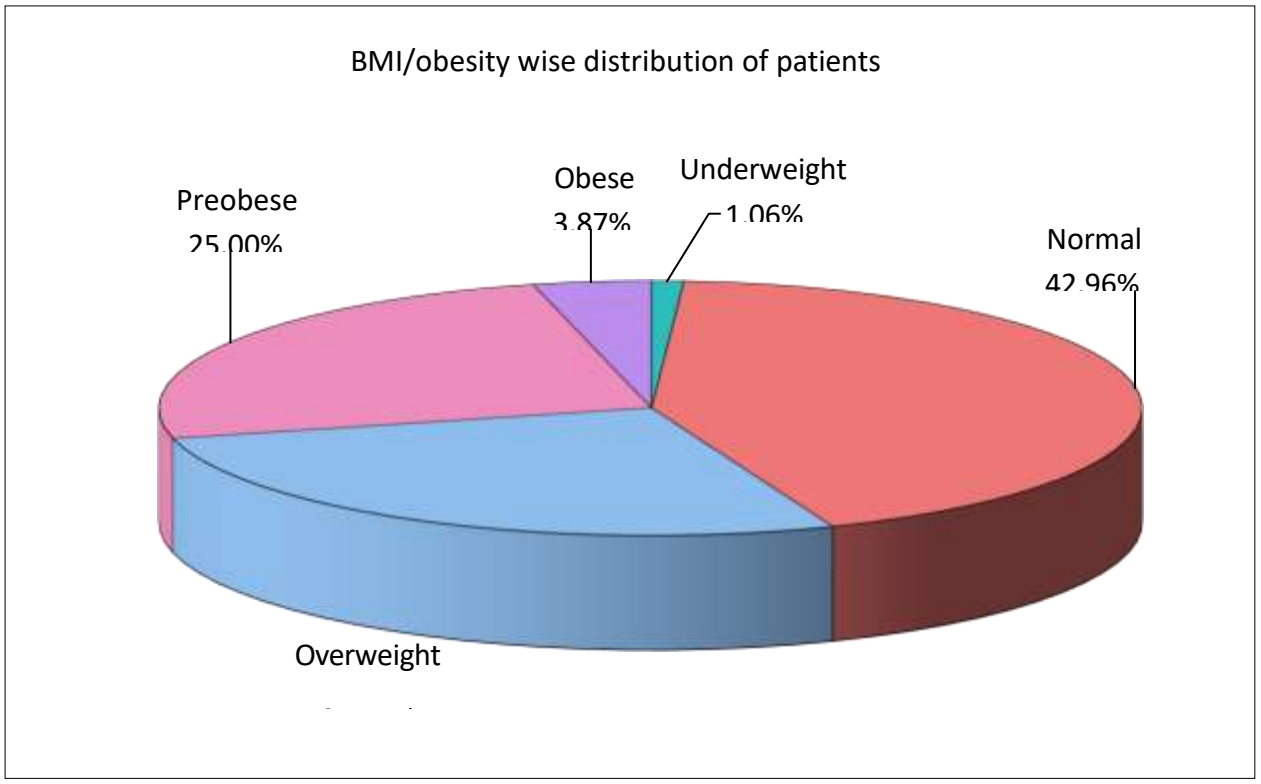


GRAPH 2-AGE WISE DISTRIBUTION OF PATIENTS

The population selected for the study was between 18-64 years. The sample obtained from the study was divided according to age group. The mean age of study population was 52.93 years and a Standard Deviation of 8.09.This data was tabulated in a table and plotted in a pie chart.

TABLE 3: BMI WISE DISTRIBUTION OF PATIENTS

BMI	No of patients	% of patients
Underweight	3	1.06
Normal	122	42.96
Overweight	77	27.11
Preobese	71	25.00
Obese	11	3.87
Total	284	100.00
Mean	23.76	
SD	3.03	

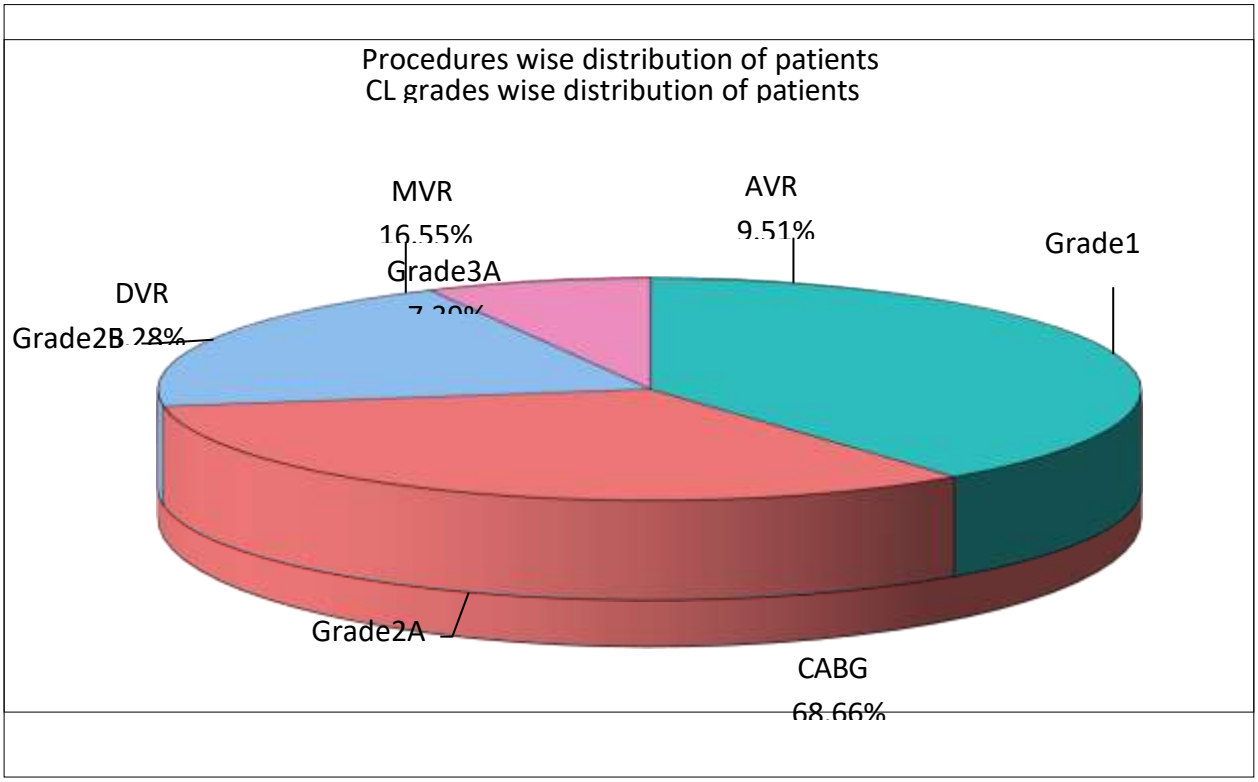


GRAPH 3- BMI/OBESITY WISE DISTRIUTION OF PATIENTS

The weight and height obtained was used to calculate the body mass index (BMI). This was further divided into underweight, normal, overweight, pre obese and obese. Mean BMI obtained from the study was 23.76 with standard deviation (SD) of 3.03.

TABLE 4: PROCEDURES WISE DISTRIBUTION OF PATIENTS

Procedure	No of patients	% of patients
AVR	27	9.51
CABG	195	68.66
DVR	15	5.28
MVR	47	16.55
Total	284	100.00



GRAPH 4: PROCEDURE WISE DISTRIBUTION OF PATIENTS

284 cardiac patients were taken into consideration of which 195 patients were cardio pulmonary bypass surgery and remaining 89 were valve replacement cases. Valve replacement cases included double valve replacement, aortic valve replacement and mitral valve replacement.

TABLE-5: CL GRADES WISE DISTRIBUTION OF PATIENTS

CL grades	No of patients	% of patients
Grade1	112	39.44
Grade2A	94	29.58
Grade2B	57	20.07
Grade3A	21	5.63
Total	284	100.00

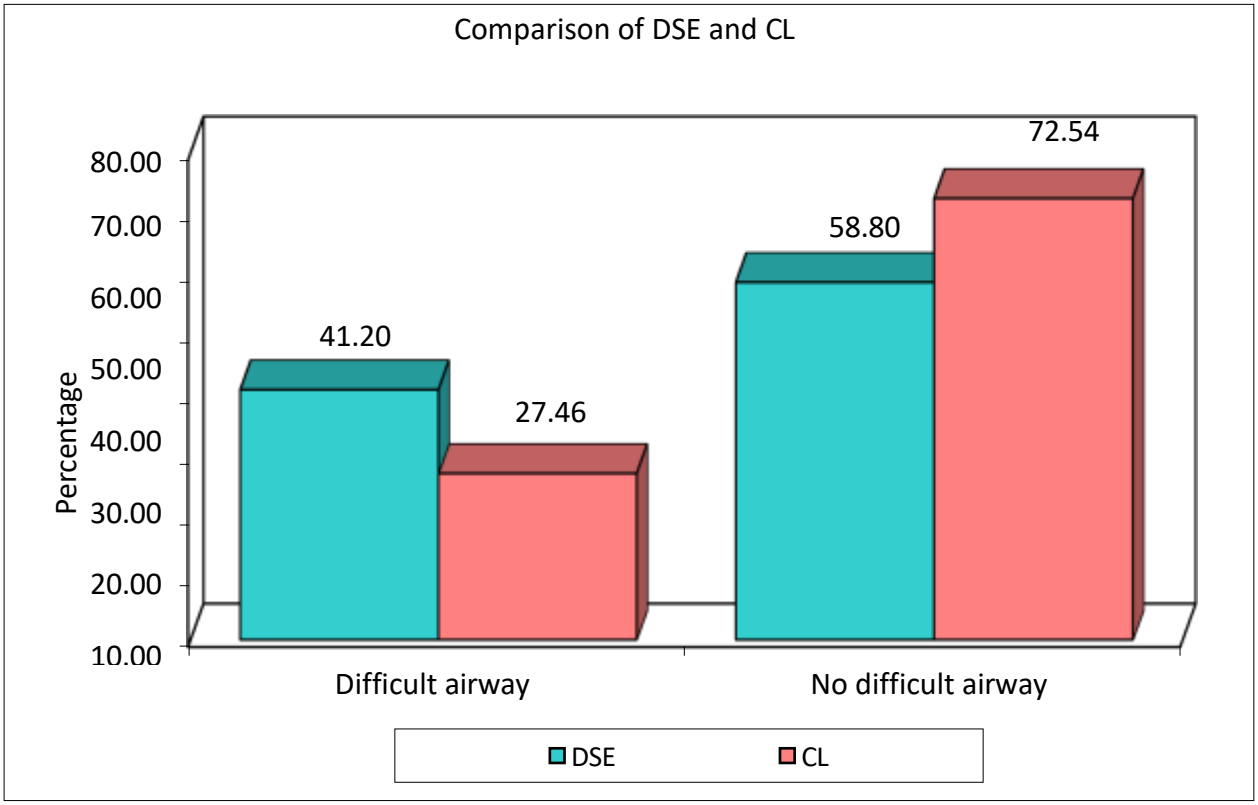
GRAPH 5: CL GRADE WISE DISTRIBUTION OF PATIENTS

Cormack Lehane grading was noted after initial laryngoscopy. 284 patients were examined in the study, of which 112 patients had CL grade 1, 94 and 57 patients belonged to CL grade 2A and 2B respectively. 31 patients had CL grade 3A. This data was further plotted in a pie chart and was used to calculate the relation between the ultrasound findings.

ANALYSIS OF VALUES OBTAINED BY ULTRASONORAPHY

TABLE 6: COMPARISONOFUS-DSEANDCL

Factors	US-DSE	%	CL	%
Difficult airway	117	41.20	78	27.46
No difficult airway	167	58.80	206	72.54
Total	284	100.00	284	100.00



GRAPH 6-COMPARISION OF DSEAND CL GRADING

117 cases were identified as difficult airway by measuring the ultrasound distance between skin and epiglottis in parasagittal plane. But on comparing with CL grading78 patients of these 117 patients had a difficult laryngoscopy. Remaining 39 patients of 117 patients identified as difficult laryngoscopy with US, had an easy laryngoscopy with CL grading either 1 or 2A. 167 patients were identified as easy laryngoscopy with both ultrasound and CL grading.

TABLE 7: SENSITIVITY AND SPECIFICITY

Statistic	Value	95% CI
Sensitivity	89.74%	80.79%to95.47%

Specificity	77.18%	70.84%to82.73%
Positive Predictive Value	59.83%	53.40%to65.94%
Negative Predictive Value	95.21%	91.12%to97.47%
Accuracy	80.63%	75.55%to85.06%

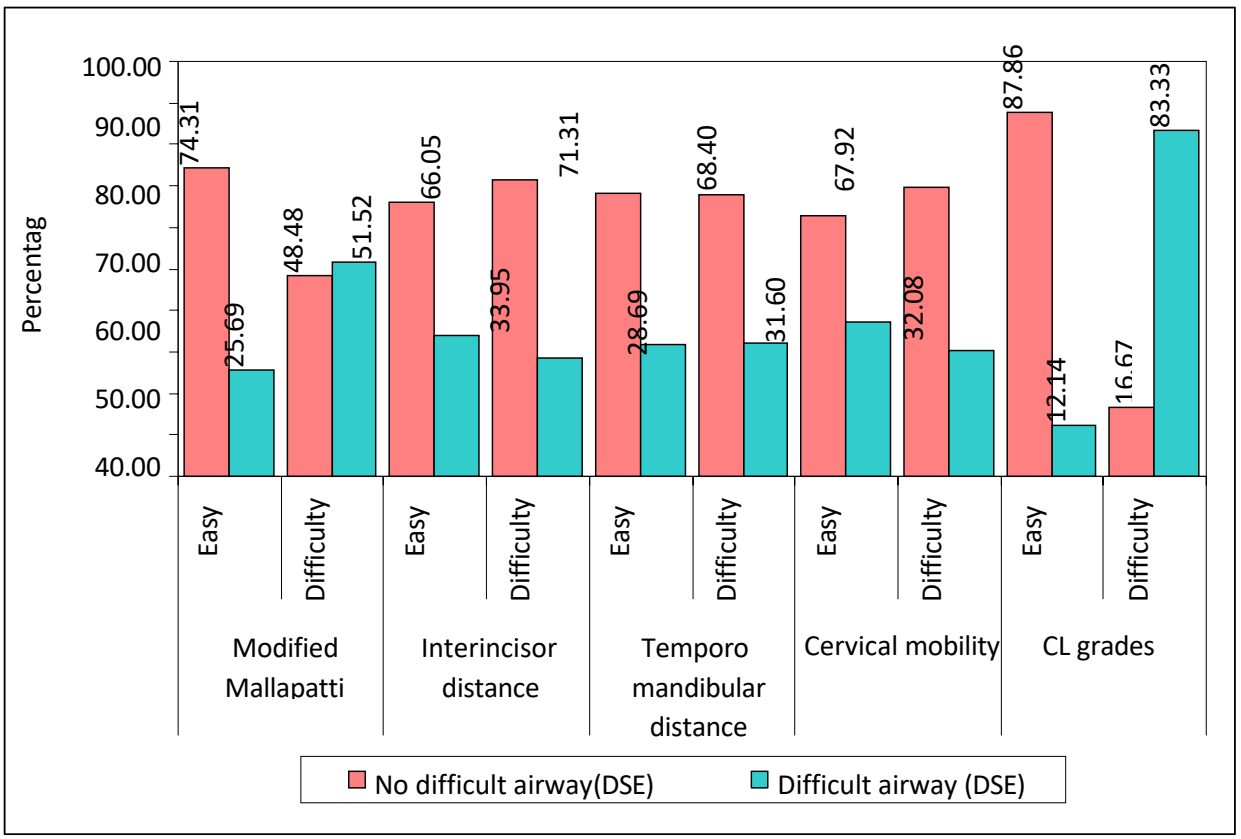
The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of US-DSE and CL grade were analyzed. Looking at the above table, sensitivity of US-DSE is 89.74%, specificity is 77.18% in identifying the difficult laryngoscopies with 80% accuracy and 59.3% positive predictive value.

TABLE 8: COMPARISON OF US-DSE (NO DIFFICULT AIRWAY AND DIFFICULT AIRWAY) WITH OTHER VARIABLES

Factors	**US-DSE**						**Chi-square**	**p- value**
	No difficult airway	**%**	**Difficult airway**	**%**	**Total**	**%**		
Modified Mallampati								
Easy	**162**	**74.31**	**56**	**25.69**	**218**	**76.76**	**15.6110**	**0.0001***
Difficult	**32**	**48.48**	**34**	**51.52**	**66**	**23.24**		
Inter incisor distance								
Easy	**107**	**66.05**	**55**	**33.95**	**162**	**57.04**	**0.8900**	**0.3450**
Difficult	**87**	**71.31**	**35**	**28.69**	**122**	**42.96**		
Temporomandibular distance								
Easy	**158**	**68.40**	**73**	**31.60**	**231**	**81.34**	**0.0040**	**0.9470**
Difficult	**36**	**67.92**	**17**	**32.08**	**53**	**18.66**		
Cervicalmobility								
Easy	**34**	**62.96**	**20**	**37.04**	**54**	**19.01**	**0.8810**	**0.3480**
Difficult	**160**	**69.57**	**70**	**30.43**	**230**	**80.99**		
CLgrades								
Easy	**181**	**87.86**	**25**	**12.14**	**206**	**72.54**	**132.484**	**0.0001***
Difficult	**13**	**16.67**	**65**	**83.33**	**78**	**27.46**		
CLgrades								

Grade1	**111**	**99.11**	**1**	**0.89**	**112**	**39.45**	**150.014**	**0.0001***
Grade 2A	**70**	**74.46**	**24**	**25.46**	**94**	**33.09**		
Grade 2B	**12**	**21.05**	**45**	**78.95**	**57**	**20.07**		
Grade 3A	**1**	**4.76**	**20**	**95.24**	**21**	**7.39**		
Total	**194**	**68.31**	**90**	**31.69**	**284**	**100.00**		

GRAPH 7: COMPARISON OF US-DSE (NO DIFFICULT AIRWAY AND DIFFICULT AIRWAY) WITH OTHER VARIABLES



According to table 13 and graph 7, US-DSE and CL grading are statistically significant with p value of < 0.0001. Of the 284 cases examined, 181 and 65 cases were identified as easy and difficult airway respectively, by both CL grading and US-DSE. 25 cases identified as difficult by US-DSE were easy intubation according to CL grading.

Among the other parameters MMS was closely related to US-DSE and was statistically significant. 162 cases had easy intubation according to both MMS and DSE and 34 had difficult intubation.

The other methods of measuring the difficult laryngoscopy like cervical mobility, inter incisor distance, temporo mandibular distance do not co relate with US-DSE and were statistically insignificant.

TABLE 9: COMPARISON OF MEAN US-DSE SCORES BY OTHER VARIABLES

Factors	n	Mean	SD	Statistic	p-value
Modified Mallampati					
Easy	218	1.74	0.22	-5.6641	0.0001*
Difficult	66	1.92	0.26		
Interincisor distance					
Easy	162	1.81	0.25	2.2364	0.0261
Difficult	122	1.74	0.23		
Temporomandibular distance					
Easy	231	1.80	0.24	1.9695	0.0499
Difficult	53	1.72	0.26		
Cervical mobility					
Easy	54	1.81	0.25	0.8069	0.4204
Difficult	230	1.78	0.24		
CL grades					
Easy	206	1.67	0.17	-17.4842	0.0001*
Difficult	78	2.07	0.17		
CL grades					
Grade1	112	1.55	0.10	196.4847	0.0001*
Grade2A	94	1.82	0.10		
Grade2B	57	2.01	0.14		
Grade3A	21	2.24	0.17		
Total	284	1.78	0.24		

*p<0.0001

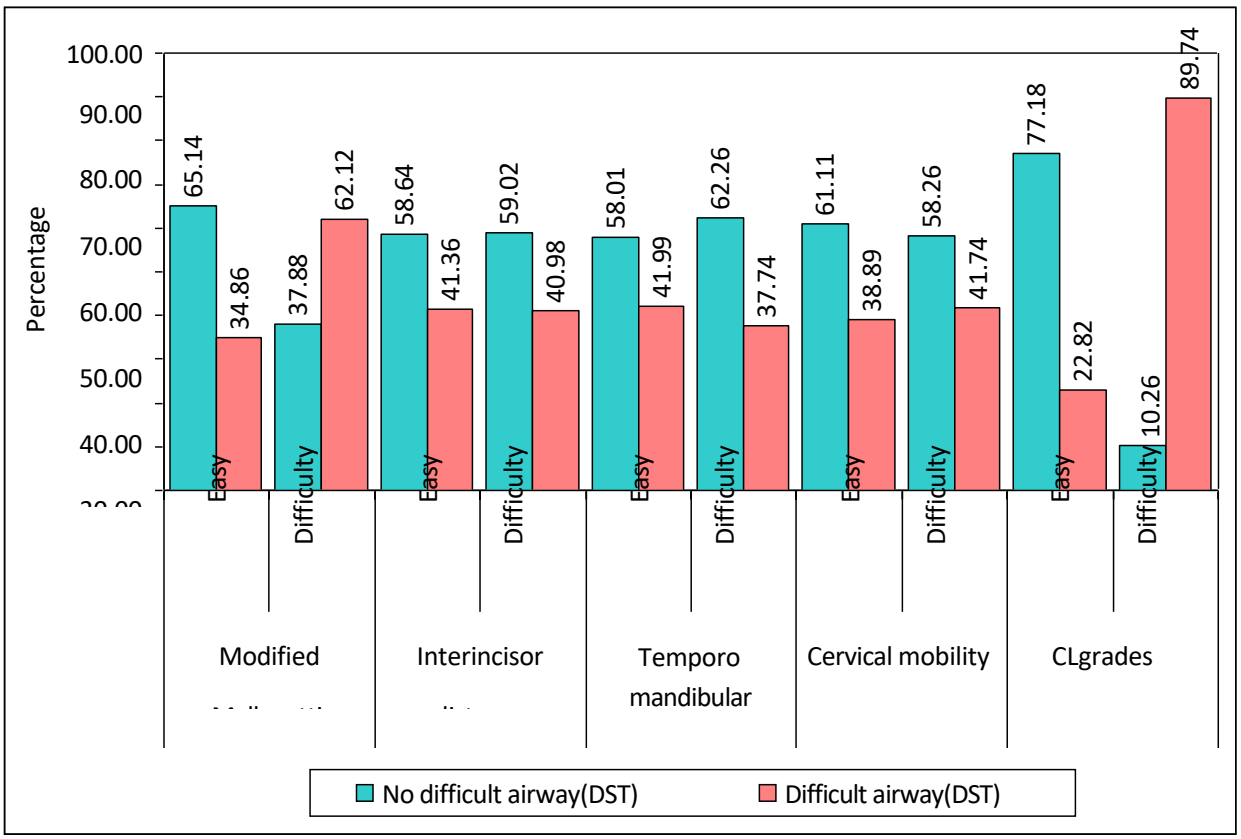
The above table signifies that mean US-DSE and CL grading are statistically significant with a p value off <0.0001. A mean of 2.07±0.17 is a case of difficult laryngoscopy. 206 cases with a mean US-DSE of 1.67±0.17 are a case of easy laryngoscopy.

TABLE 10: COMPARISON OF US-DST (NO DIFFICULT AIRWAY AND DIFFICULT AIRWAY) WITH OTHER VARIABLES

Factors	US-DST						Chi-square	p-value
	No difficult airway	%	Difficult airway	%	Total	%		
Modified Mallampati								
Easy	142	65.14	76	34.86	218	76.76	15.5390	0.0001*
Difficult	25	37.88	41	62.12	66	23.24		
Interincisor distance								
Easy	95	58.64	67	41.36	162	57.04	0.0040	0.9490
Difficult	72	59.02	50	40.98	122	42.96		
Temporomandibular distance								
Easy	134	58.01	97	41.99	231	81.34	0.3220	0.5700
Difficult	33	62.26	20	37.74	53	18.66		
Cervical mobility								
Easy	33	61.11	21	38.89	54	19.01	0.1470	0.7020
Difficult	134	58.26	96	41.74	230	80.99		
CL grades								
Easy	159	77.18	47	22.82	206	72.54	104.615	0.0001*
Difficult	8	10.26	70	89.74	78	27.46		
CL grades								
Grade 1	106	94.64	6	5.36	112	39.44	139.960	0.0001*
Grade 2A	53	59.55	36	40.45	89	29.58		
Grade 2B	8	12.90	54	87.10	62	20.07		
Grade 3A	0	0.00	21	100.0	21	5.63		
Total	167	58.80	117	41.20	284	100.00		

*p<0.05

GRAPH 8: COMPARISON OF US-DST (NO DIFFICULT AIRWAY AND DIFFICULT AIRWAY) WITH OTHER VARIABLES



According to table 15 and graph 8, US-DST and CL grading are statistically significant with p value of < 0.0001. Of the 284 cases examined, 159 and 70 cases were identified as easy and difficult airway respectively, by both CL grading and US-DST. 8 cases identified as difficult by CL grading were easy intubation according to US-DST.

Among the other parameters MMS was closely related to US-DST and was statistically significant. 142 cases had easy intubation according to both MMS and DST and 41 had difficult intubation.

The other methods of measuring the difficult laryngoscopy like cervical mobility, inter incisor distance, temporo mandibular distance do not co relate with US-DST and were statistically insignificant.

TABLE 11: COMPARISON OF MEAN US-DST SCORES BY OTHER VARIABLES

Factors	n	Mean	SD	Statistic	p-value
Modified Mallapatti					
Easy	**218**	**0.90**	**0.19**	**-5.1381**	**0.0001***
Difficult	**66**	**1.04**	**0.25**		
Interincisor distance					
Easy	**162**	**0.94**	**0.22**	**1.3087**	**0.1917**
Difficult	**122**	**0.91**	**0.19**		
Temporomandibular distance					
Easy	**231**	**0.94**	**0.21**	**1.6884**	**0.0924**
Difficult	**53**	**0.89**	**0.20**		
Cervical mobility					
Easy	**54**	**0.95**	**0.24**	**0.7163**	**0.4744**
Difficult	**230**	**0.93**	**0.20**		
CL grades					
Easy	**206**	**0.85**	**0.14**	**-13.9625**	**0.0001***
Difficult	**78**	**1.15**	**0.21**		
CL grades					
Grade 1	**112**	**0.78**	**0.11**	**85.1543**	**0.0001***
Grade 2A	**90**	**0.90**	**0.11**		
Grade 2B	**61**	**1.08**	**0.17**		
Grade 3A	**21**	**1.31**	**0.20**		
Total	**284**	**0.93**	**0.21**		

***p<0.0001**

The above table signifies that mean US-DST and CL grading are statistically significant with a p value off <0.0001. US-DST in the range of 0.85±0.14 is an independent predictor of ease of intubation with a p value of <0.0001 on comparison with CL grade.

TABLE 12: COMPARISON OF US-DTE (NO DIFFICULT AIRWAY AND DIFFICULT AIRWAY) WITH OTHER VARIABLES

FACTORS	US-DTE						CHI-SQUARE	P-VALUE
	NO DIFFICULT AIRWAY	%	DIFFICULT AIRWAY	%	TOTAL	%		
MODIFIED MALLAMPATI								
EASY	64	29.36	154	70.64	218	76.76	4.1990	0.0001*
DIFFICULT	11	16.67	55	83.33	66	23.24		
INTERINCISOR DISTANCE								
EASY	43	26.54	119	73.46	162	57.04	0.0040	0.9530
DIFFICULT	32	26.23	90	73.77	122	42.96		
TEMPOROMANDIBULAR DISTANCE								
EASY	63	27.27	168	72.73	231	81.34	0.4760	0.4900
DIFFICULT	12	22.64	41	77.36	53	18.66		
CERVICAL MOBILITY								
EASY	17	31.48	37	68.52	54	19.01	0.8830	0.3470
DIFFICULT	58	25.22	172	74.78	230	80.99		
CLGRADES								
EASY	72	34.95	134	65.05	206	72.54	28.1670	0.0001*
DIFFICULT	3	3.85	75	96.15	78	27.46		
CLGRADES								
GRADE1	51	45.54	61	54.46	112	39.44	46.8100	0.0001*
GRADE2A	21	22.34	73	77.66	94	33.1		
GRADE2B	2	3.51	55	96.49	57	20.07		
GRADE3A	1	4.76	20	95.24	21	7.39		
TOTAL	75	26.41	209	73.59	284	100.00		

According to table 17 and graph 9, US-DTE and CL grading are statistically significant with p value of < 0.0001. Of the 284 cases examined, 72 and 75 cases were identified as easy and difficult airway respectively, by both CL grading and US-DTE. 134 cases identified as difficult by CL grading were easy intubation according to US-DTE.

Among the other parameters MMS was closely related to US-DTE and was statistically significant. 64 cases had easy intubation according to both MMS and DTE and 55 had difficult intubation

The other methods of measuring the difficult laryngoscopy like cervical mobility, inter incisor distance, temporo mandibular distance do not co relate with US-DTE and were statistically insignificant.

In the receiver operating curve analysis, on the x- axis we plot 1– specificity and on y- axis we plot sensitivity. Area under curve of DSE was higher than DTE and DST indicating that it is a better predictor of difficult airway.

TABLE 13: SUMMARY OF ALL NUMERICAL VARIABLES

Variables	Minimum	Maximum	Range	Mean	Std. Dev.
Age	30.00	64.00	34.00	52.93	8.09
Weight	45.00	92.00	47.00	64.19	8.24
Height	148.00	178.00	30.00	164.46	5.89
BMI	16.53	35.94	19.41	23.76	3.03
US-DSE	1.41	2.44	1.03	1.78	0.24
US-DST	0.57	1.88	1.31	0.93	0.21
US-DTE	0.45	0.99	0.54	0.67	0.12

TABLE 14: SUMMARY OF AIRWAY ASSESSMENT RESULTS

VARIABLES	**EASY INTUBATION**	**DIFFICULT INTUBATION**	**P VALUE**
US-DSE(cms)	**1.67±0.17**	**2.07±0.17**	**<0.001**
US-DST(cms)	**0.85±0.14**	**1.15±0.21**	**<0.001**
US-DTE(cms)	**0.62±0.09**	**0.78±0.11**	**<0.001**

The above table can be used to interpret the results of airway assessment. The cut off values for different ultrasound values is mentioned in the above table. The distance measured in centimetres (cms) gives us an idea of the ease of intubation using ultrasound in parasagittal plane.

DISCUSSION

Unanticipated difficult airway has been recognized as a major contributory factor to anaesthesia related morbidity and mortality. There are several traditional tests and indices for predicting difficult laryngoscopy, but none of them have 100% sensitivity and specificity. The search for a predictive test that has ease of applicability and accuracy of prediction persists.

There are various screening tests to predict difficult intubation. Many studies proved their poor diagnostic accuracy when they were used alone. Hence combinations of individual tests may add diagnostic value in comparison with the value of each test alone.

With the introduction of portable ultrasound in anaesthesia practice many studies are being conducted to explore the feasibility of ultrasound in airway evaluation and management.

Expensive imaging techniques like CT, MRI can accurately measure the parameters of airway. So they are not cost effective and not practical in the operating rooms. Due to the easy availability, portability and convenience, point of care ultrasound can be used in the operating room for airway assessment.

Moreover, for patients who cannot participate actively for airway assessment, ultrasound can be an additional tool to predict difficult laryngoscopy and intubation.

In this prospective observational study we tried to compare the distance between skin and epiglottis (US-DSE) obtained by ultrasonography in para sagittal plane and Cormack Lehane grading to find out the ease of intubation. We also tried to establish a relationship between various other parameters measured by ultrasound in parasagittal plane to standard airway examination parameters as a secondary objective.

Our study was able to establish a statistically significant relationship between US-DSE and CL grade with a p value of <.0001. In this study, a US-DSE measurement of 2.07±0.17, obtained in the parasagittal plane was considered as a difficult airway with a CL grading of 2B or more. A distance of 1.67±0.17 was considered as easy intubation based on CL grading of 1 or 2A. Thus we were able to prove that US-DSE was a helpful tool in measuring the difficult airway independently. On combining with non-invasive methods like MMS, US-DSE was statistically significant with p value of <0.0001.

Hall E A et al performed a study on Ultrasound evaluation of the airway in the emergency room and they came to the conclusion that ultrasound scanning protocol by emergency sonologists demonstrates that the airway can be measured with good reliability in all but epiglottic thickness.

Hongwei Ni, Chunming Guan, Guangbao He, Yang Bao, Dongping Shi and Yijun Zhuet al. in their study state, measured parameters namely distance between skin and epiglottis, skin and thyroid and thyroid and epiglottis distance. They have said that distance between skin and epiglottis (US-DSE) in parasagittal plane is an independent predictor of a difficult laryngoscopy in Chinese adults. A US-DSE cut off value of 2.36 cm is a better predictor of a difficult laryngoscope than other ultrasound or physiological measurements for predicting a difficult laryngoscope in parasagittal plane[5]. This study was taken into consideration and applied to Indian population.

In our study we found a co relation between US-DSE and CL grading. A US-DSE value of 2.07±0.17 was found to have a p value of < 0.001, signifying difficult airway. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of US-DSE and CL grade were analyzed. US-DSE was more specific in identifying the difficult laryngoscopies with 80% accuracy and 59.3% positive predictive value.

CONCLUSION

Ultrasound laryngoscopy is a simple and non-invasive tool to measure the difficult laryngoscopy. In our study US-DSE had good sensitivity, specificity and positive predictive value and can be used as an independent predictor of difficult laryngoscopy. US-DSE when used along with MMS, can prove to be a useful predictor of difficult airway with good sensitivity and specificity. Among the non-invasive parameters, MMS grading was closely related to the ultrasound parameters US-DSE, US-DTE and US- DST. US-DSE can be used as an independent predictor of difficult laryngoscopy than other USG parameters. Thus we conclude that ultrasonography in parasagittal plane can be used as an additional tool for prediction of difficult laryngoscopy along with MMS.

REFERENCES

1. Crawley SM, Dalton AJ. Predicting the difficult airway. BJA Educ [Internet]. 2015;15(5):253–8. Available from: http://dx.doi.org/10.1093/bjaceaccp/mku047

2. Etezadi F, Ahangari A, Shokri H, Najafi A, Khajavi MR, Daghigh M, et al. Thyromental height: A new clinical test for prediction of difficult laryngoscopy. Anesth Analg[Internet].2013;117(6):1347–51.

3. Osman A, Sum KM. Role of upper airway ultrasound in airway management. J Intensive Care [Internet]. 2016;4(1):52.

4. You-Ten KE, Siddiqui N, Teoh WH, Kristensen MS. Point-of-care ultrasound (POCUS) of the upper airway. Can J Anaesth [Internet]. 2018;65(4):473–84. 5. NiH, GuanC, He G,BaoY,Shi D, ZhuY. Ultrasound measurement of laryngeal structures in the parasagittal plane for the prediction of difficult laryngoscopies in Chinese adults. BMC Anesthesiol [Internet]. 2020;20(1):134.

6. Lunus-Dstrøm LH, Vester-Andersen M, Møller AM, Charuluxananan S, L'hermite J, Wetterslev J. Poor prognostic value of the modified Mallampati score: a meta-analysis involving 177088 patients. British Journal of Anaesthesia.2011;107(5):659– 67.

7. Sharma S, Mehta N, Charak D. Comparative evaluation of airway assessment tests and their correlation with laryngoscopy. IndianJClinAnaesth [Internet]. 2015;2(1).

8. Hillman DR, PlattPR, Eastwood PR. The upper airway duringanaesthesia. Br J Anaesth[Internet].2003;91(1):31-9.

9. Merah NA, Foulkes-Crabbe DJO, Kushimo OT,Ajayi PA. Prediction of difficult laryngoscopy in a population of Nigerian obstetric patients. West Afr J Med [Internet]. 2004;23(1):38–41.

10. Eberhart LHJ, Arndt C, Cierpka T, Schwanekamp J, Wulf H, Putzke C. The reliability and validity of the upper lip bite test compared with the Mallampati classification to predict difficult laryngoscopy : an external prospective evaluation. Anesth Analg [Internet]. 2005;101(1):284–9, table of contents.