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Role of Ultrasound in Anaesthesia Related Airway Assessment - An Observational Study

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1. Introduction

- Airway management is the core of safe anaesthetsia practice. One of the fundamental responsibilities of an anaesthesiologist is to mitigate the adverse effects of anaesthesia on the respiratory system by maintaining airway patency and ensuring adequate ventilation and oxygenation.
- The term AIRWAY MANAGEMENT refers to this practice and is a cornerstone of anaesthesia management. Successful airway management requires a range of knowledge and skill sets, specifically, the ability to predict difficulty with airway management and to formulate an airway management plan.

Ultrasound has been applied in management of airway in different ways which include the following:[28]

- Assessment of the diameter of the subglottic airway and prediction of endotracheal tube size.
- Prediction of difficult laryngoscopy in obese patients.
- Role of US in percutaneous dilatational tracheostomy.
- Prediction of post extubation stridor.
- Elective trans tracheal cannulation and emergency cricothyrotomy.
- US guided upper airway anaesthesia to facilitate awake intubation.
- Endotracheal intubation, oesophageal intubation, and double lumen bronchial tube placement.

2. Aims and Objective

The **Primary aim** of the study is to:

1) Perform a pre operative upper airway assessment using Ultrasonography (USG).
2) Compare and correlate the ultrasonographic view of the larynx ie; Soft tissue thickness at the level of a). Hyoid bone b). Pre epiglottic space c).True Vocal Cords with the Mallampati classification measured preoperatively and predict a difficult intubation.
3) Comparison with Cormack-Lehane(CL) classification during direct laryngoscopy under general anaesthesia.

Structure	Anatomy	Sonoanatomy
Hyoid Bone	Horseshoe shaped bone at the ant. Midline of the neck. Lies at the level of the C3 vertebrae. Has a body and 2 sets of horn.	Identified in the transverse plane as a Hyperechoic structure with a hypoechoic U-shaped halo.
Epiglottis	Long feather shaped fibroelastic cartilage attached at its inferior end to the inner surface of thyroid cartilage lamina just above the ant. Commissure.	Cross section visualized with high frequency linear probe at the thyro-hyoid space as hypoechoic U-shaped image preceded at the ant. margin by a hyperechoic pre epiglottic space.
Thyroid Cartilage	Two rectangular laminae fused anteriorly in the midline. Attached to each lamina posteriorly is the superior and inferior is cornua. Inferior cornu articulates with the cricoid cartilage.	Visualized in the transverse axis as a hypoechoic structure with respect to the vocal cords followed by an acoustic shadow corresponding to the airway.
Cricoid Cartilage	Singlet ring shaped cartilage and the only cartilage encircling the airway completely. Articulates with the thyroid cartilage superiorly and tracheal rings inferiorly with a membranous attachment.	Hypoechoic inverted U-shaped structure inferior to thyroid cartilage, posterior acoustic shadow corresponds to the airway *Transverse measurements of this window help to select the correct size ETT.*
Cricothyroid Membrane	Membranous attachment between the inferior border of the thyroid to the superior border of cricoid cartilage.	Hypoechoic structure between the thyroid and cricoid cartilages in the longitudinal sections.
Tracheal Rings	Cartilaginous (hyaline) rings that surround the trachea, deficient posteriorly.	Semi-circular hypoechoic structures that can be seen in the longitudinal axis “string of beads” and inverted U shape in the transverse plane.
Vocal Cords	Twin pearly white infoldings of mucous membrane stretched horizontally from back to front across the larynx. Lies closer to the lower border of the thyroid cartilage lamina. Attached post. to the arytenoid cartilage and ant. to the thyroid cartilage. Above the VC appear the two vestibular folds/false VC which have a small sac between them.	Seen best using the thyroid cartilage as a window in the transverse plane. Appears as an isosceles triangle with a central tracheal shadow. They are delineated medially by the hyperechoic vocal ligaments. False VC lie parallel and cephalad to the true VC and are more hyperechoic in appearance.

3. Materials and Methodology

- Patients with age < 18 years, emergency surgeries, requiring Rapid sequence intubation, with H/Ocervical spine pathology, Fiberoptic tracheal intubation, having airway pathologies (maxilla-facial fractures, tumors etc), uncooperative patients and pregnant ladies were excluded from the study.
- USG assessment of the airway was done pre operatively (Transverse/Longitudinal plane) using a SonoSite M-Turbo USG system, probe-Linear 13-6MHz keeping the patient in supine position with neck extension. The following parameters were measured:

Measurements of USG parameters and description of landmarks[8]

USG assessment and the measured parameters were utilized to classify the airway as normal or difficult airway preoperatively.

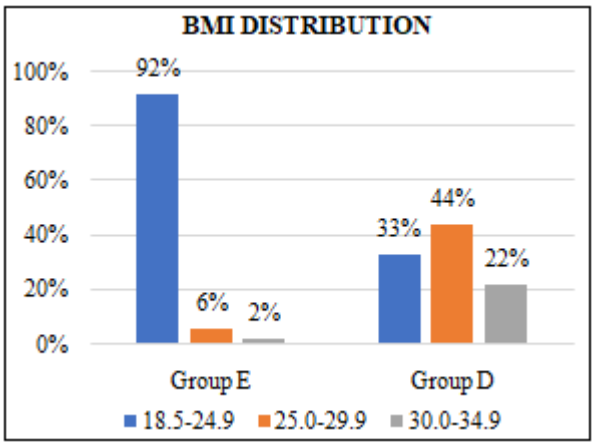
Ultrasound Parameters	Measurements	Ultrasound Landmarks
Soft tissue thickness at level of hyoid bone **(ANS-H)**	Measured from skin to anterior surface of hyoid bone	Hyoid bone appears as a hyperechoic line with posterior acoustic shadow
Soft tissue thickness at level of true vocal cords **(ANS-VC)**	Measured from skin to anterior commisure of true vocal cords	True vocal chords appear as triangular hypoechoic structures with hyperechoic vocal ligaments at their medial border. Anterior commisure is the point where the true vocal cords meet anteriorly.
Pre epiglottic space **(Pre E)**	Measured from the anterior surface of the epiglottis to the anterior surface of the strap muscle.	Epiglottis appears as a hypoechoic curvilinear line in short axis with hyperechoic A-M interface at its posterior surface and hyperechoic preepiglottis space anteriorly
Internal diameter at the lower border of Cricoid **(ID-T)**	Measured as the transverse diameter at the lower border of the cricoids cartilage in horizontal plane.[9]	The cricoid cartilage is a hypoechoic, inverted U structure inferior to the thyroid cartilage; the posterior acoustic shadow corresponds to the airway. The window is more important to take transverse measurements and to select the size of the endotracheal tube [9]
E-VC	Measured from posterior surface of epiglottis to the mid point of the vocal cords	Epiglottis appears as a hypoechoic curvilinear line in short axis with hyperechoic A-M interface at its posterior surface and hyperechoic preepiglottis space anteriorly.

4. Observation and Results

- CL grade 1 and 2a = GROUP E = 51/60 patients
- CL grade 2b ,3 and 4 = GROUP D = 9/60 patients

BMI

BMI (Kg/M2)	Group E		Group D	
	No.	%	No.	%
18.5-24.9	47	92%	3	33%
25.0-29.9	3	6%	4	44%
30.0-34.9	1	2%	2	22%
Total	51	100%	9	100%
Mean BMI	Mean	SD	Mean	SD
	22.35	2.33	27.16	4.42
P Value	< 0.0001			

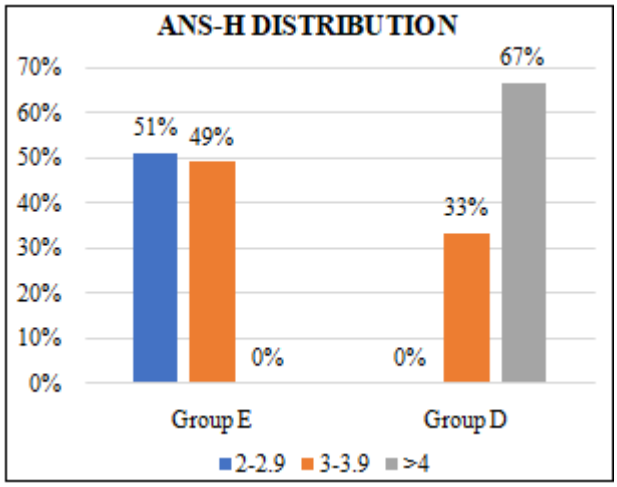


Easiness of intubation according to CL grade, mouth opening and mallampatti grading parameters

Parameter	No. of Cases	Percentage
CL Grade		
Grade 1 & 2a (EASY)	51	85%
Grade 2b & 3 (DIFFICULT)	9	15%
MOUTH OPENING		
< 3Finger	11	18%
≥ 3 Finger	49	82%
MPG		
Grade 1	44	73%
Grade 2	13	22%
Grade 3	3	5%

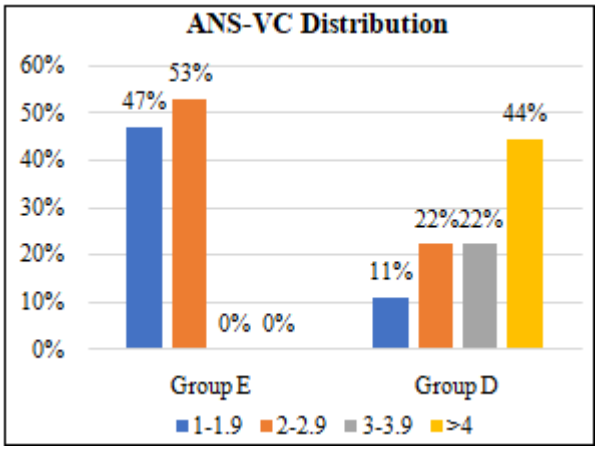
Anterior neck soft tissue at the level of hyoid bone (ANS-H)

ANS-H (mm)	Group E		Group D	
	No.	%	No.	%
2-2.9	26	51%	0	0%
3-3.9	25	49%	3	33%
>4	0	0%	6	67%
Total	51	100%	9	100%
Mean ANS-H	Mean	SD	Mean	SD
	3.12	0.58	4.14	0.74
P Value	P< 0.0001			



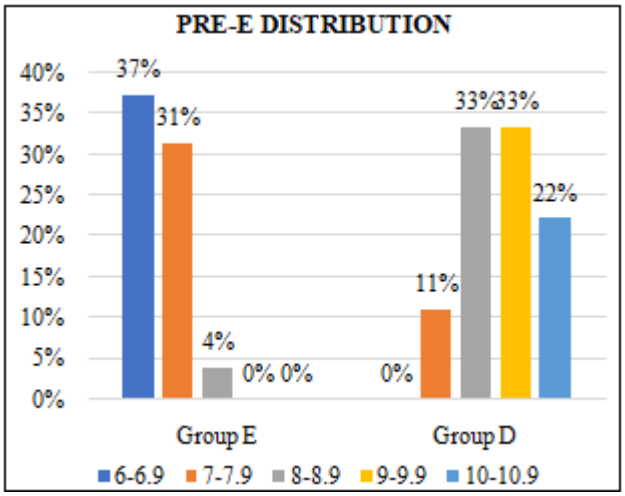
Anterior Neck Soft Tissue at the Level of Vocal Cords: (ANS-VC)

ANS-VC (mm)	Group E		Group D	
	No.	%	No.	%
1-1.9	24	47%	1	11%
2-2.9	27	53%	2	22%
3-3.9	0	0%	2	22%
>4	0	0%	4	44%
Total	51	100%	9	100%
Mean ANS-VC	**Mean**	**SD**	**Mean**	**SD**
	2.09	0.71	3.56	1.16
P Value	P= <0.0001			



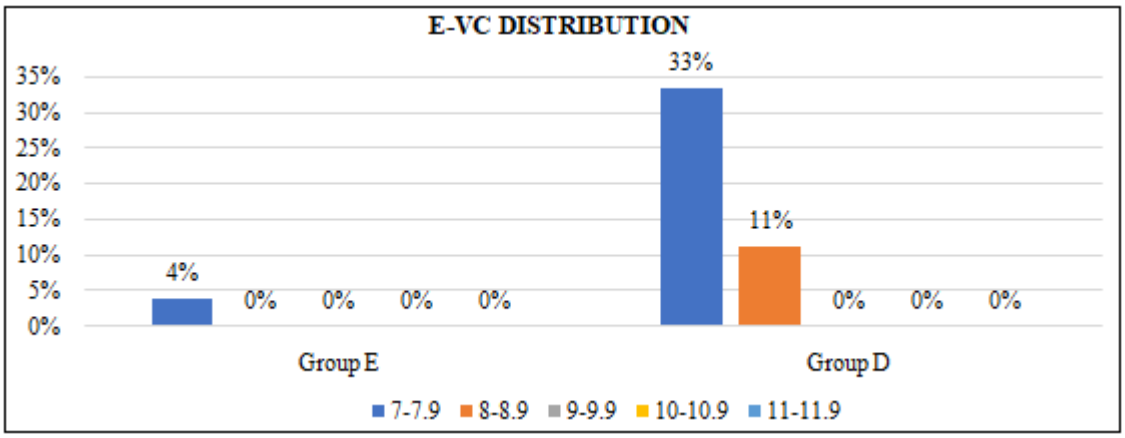
Pre Epiglottic Space

PRE-E (mm)	Group E		Group D	
	No.	%	No.	%
5-5.9	14	27%	0	0%
6-6.9	19	37%	0	0%
7-7.9	16	31%	1	11%
8-8.9	2	4%	3	33%
9-9.9	0	0%	3	33%
10-10.9	0	0%	2	22%
11-11.9	0	0%	0	0%
12-12.9	0	0%	0	0%
Total	51	100%	9	100%
Mean PRE-E	Mean	SD	Mean	SD
	6.68	0.94	9.33	0.87
P Value	<0.0001			



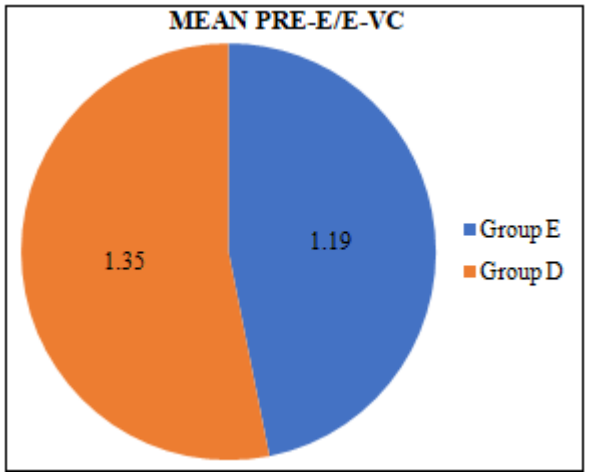
Distance between epiglottis and mid point of Vocal Cords (E-VC):

E-VC (mm)	Group E		Group D	
	No.	%	No.	%
4-4.9	14	27%	0	0%
5-5.9	19	37%	1	11%
6-6.9	16	31%	4	44%
7-7.9	2	4%	3	33%
8-8.9	0	0%	1	11%
9-9.9	0	0%	0	0%
10-10.9	0	0%	0	0%
11-11.9	0	0%	0	0%
12-12.9	0	0%	0	0%
13-13.9	0	0%	0	0%
14-14.9	0	0%	0	0%
15-15.9	0	0%	0	0%
16-16.9	0	0%	0	0%
Total	51	100%	9	100%
Mean E-VC	**Mean**	**SD**	**Mean**	**SD**
	5.64	0.91	6.94	0.68
P Value	0.000142316			



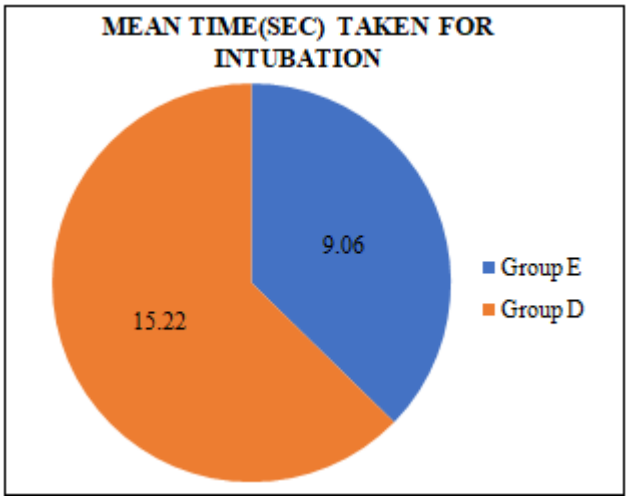
Ratio of Pre-E/E-VC:

PRE-E/E-VC	Group E		Group D	
Mean PRE-E/E-VC	Mean	SD	Mean	SD
	1.19	0.11	1.35	0.16
P Value	0.000467342			



Time Taken to Intubate

Time Taken for Intubation	Group E		Group D	
Mean Time Taken for Intubation	Mean	SD	Mean	SD
	9.06	0.76	15.22	2.91
P Value	<0.0001			



Assistance:

Assistance	Group E		Group D	
	No.	%	No.	%
More than 1 Attempt	8	16%	4	44%
Use of stylet/Bougie	1	2%	5	56%
Difficult Mask Ventilation	0	100%	4	44%
Stridor	0	0%	0	0%

5. Discussion

1) Recognising before anaesthesia the potential for a difficult airway allows time for optimal preparation, proper selection of equipment and technique and participation of personnel experienced in difficult airway management.
2) The currently available non invasive screening tests for airway assessment during pre- operative airway examination are Mouth Opening, Mallampati Grading, Thyromental distance, Atlanto-occipital extension.
3) The Cormack Lehane classification is frequently used to describe the best view of the larynx during laryngoscopy. one major drawback is that itcan not be applied for predicting difficult intubation in patients undergoing intubation for the first time.
4) Direct laryngoscopy is simply too invasive technique to be used to assess and classify an airway in an awake patients..
5) In our study a total of 60 patients posted for elective surgery under General Anaesthesia. Patients with limited neck movement, mouth opening, cervical pathology or surgery, facio-maxillary injury, thyroid/neck swelling were excluded.
6) PAC was emphasised on airway assessment ie; Mallampati classification [MP] and Mouth opening. USG assessment of the airway was done pre operatively and soft tissue thickness at various levels in the neck was noted.

6. Summary and Conclusion

The prospective observational study conducted to assess the utility of ultrasonogram in predicting difficult airway preoperatively concluded that:

1) Among the demographic variables, obesity is associated with difficult intubation.
2) Ultrasonogram can be used to predict difficult airway preoperatively by measuring anterior neck soft tissue thickness.

3) Increase in the anterior neck soft tissue thickness correlates with the increasing difficulty of intubation.
4) Measurements taken at the thyrohyoid membrane level (Epiglottis) is a better predictor of difficult airways.

Thus, implementation of ultrasonographic airway assessment along with the conventional technique would drastically reduce the incidence of unanticipated difficult airway there by enabling better management.

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