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Temporal comparison of real-time ultrasound vs capnography and auscultation in confirmation of endotracheal placement

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Abstract

Background: Maintaining a patent airway is a prime responsibility of an anesthesiologist. Interruption of gas exchange, even for few minutes can lead to catastrophic events like brain damage or even death

Methods: Prospective Observational **conducted at** Department of Anesthesiology, Dr. RPGMC Kangra at Tanda, Himachal Pradesh.

Results: There was a significant difference in time taken by USG in seconds for confirmation of endotracheal intubation (P=0.000) of the patients in grade 1 (29.17±.575), grade 2 (29.56±.564), grade 3 (32.65±1.032), and grade 4 (33.78±1.202).Time taken by Capnography in seconds for confirmation of endotracheal intubation was statistically significantly different (P=0.000) in grade 1 (37.31±.577), grade 2 (37.65±.607), grade 3 (41.24±.902), and grade 4 (42.67±.866)

Conclusion: Ultrasound is better and fast than other method for endotracheal intubation.

Keywords: Ultrasound, endotracheal intubation, direct laryngoscopy

Introduction

Maintaining a patent airway is a prime responsibility of an anesthesiologist. Interruption of gas exchange, even for few minutes can lead to catastrophic events like brain damage or even death.[1] Theoretically, accurate preoperative airway evaluation can reduce or avoid unanticipated difficult intubation. However, the difficult laryngoscopy and tracheal intubation rate still remains at 1.5–13% due to poor reliability of traditional protocols, algorithms, and combinations of screening tools in identifying a potentially difficult airway.[2]

Unexpected difficult intubations are probably a result of lack of accurate predictive tests for difficult intubation of airway performed preoperatively. In an attempt to predict the likelihood of ease or difficulty of orotracheal intubation, Dr Mallampati[3] introduced the concept of a simple scoring system based on a non-invasive, direct visual examination of the patient's airway. Despite limitations, the Mallampati scoring system remains one of the most commonly used assessment tools for evaluating a patient's airway.

With increasing awareness, portability, accessibility and further sophistication in technology, it is likely to find a place in routine airway management. There is a need for further evaluating the optimal combination of ultrasound-guided screening tests including HMDR, Pre E/E-VC and other ultrasound guided predictors like anterior soft tissue neck thickness at the level of hyoid and vocal cord, as diagnostic predictors for the assessment of difficult intubations, in the preoperative period.

Therefore, this study was undertaken to evaluate a combination of various US-guided airway assessment parameters, in an attempt to assess the airway, at the point of care ultrasound in patients for general anesthesia.

Material and Methods

Type of Study- Prospective Observational

Place of Study–Department of Anesthesiology, Dr. RPGMC Kangra at Tanda, Himachal Pradesh

Study Population– After approval by institutional ethics committee and obtaining informed consent, prospective and observational study was carried out over the period of one year.

Inclusion criteria

1. Males and females between the age group 18-60 years.
2. ASA physical class I-II.
3. BMI 18.5-29.9.

Exclusion criteria

1. Patient's refusal to participate in the study
2. Rapid-sequence induction of anesthesia
3. Inability to open the mouth due to existing trauma or medical condition, preexisting neck or facial disease-causing distortion of the airway, edentulous, and/or a history of difficult intubation
4. Altered level of consciousness, confusion, or inability to follow commands
5. Preexisting limitation or pain with cervical spine movement. Patients requiring rapid-sequence induction are already at high risk for aspiration; the airway should be rapidly secured with an endotracheal tube and not subjected to repeated or delayed assessment as might occur in the study.

Blinding

The interpreter reliability was double-blinded, that is, the anesthesiologist assessing glottic exposure and the investigator recording the observations were blinded to the preoperative sonographic airway assessment results.

Methodology

The enrolled patients underwent sonographic assessment of airway by the anesthesiologist in the pre-operative holding area. The ultrasound view of the airway of all study patients was assessed with a high-frequency linear probe or low frequency curved probe (SonoSite® MicroMaxx® ultrasound system (SonoSite INC, Bothell, WA). The following measurements were obtained with the patient in supine position and head and neck in a neutral position:

1. A curved low-frequency (5-MHz) transducer was used to visualize the tongue and shadows of the hyoid bone and mandible. The mentum and hyoid bone appear in midsagittal scans as hyperechoic structures with hypoechoic shadowing. The hyomental distances in the neutral and head-extended positions were measured from the upper border of the hyoid bone to the lower border of the mentum in the neutral and extended head positions.

2. The thicknesses of anterior neck soft tissue at the hyoid bone and the thyrohyoid membrane were obtained transversely across the anterior surface of the neck with a 13–6 MHz linear array ultrasound probe attached to a SonoSite S-nerve machine (SonoSite Inc., Bothell, WA, USA). At hyoid bone level, the minimal distance from the hyoid bone to the skin surface (DSHB) was measured and at thyrohyoid membrane

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level, the distance from skin to epiglottis midway (DSEM) between the hyoid bone and thyroid cartilage was measured.

3. The following measurements were obtained with the oblique-transverse ultrasound view of the airway: (a) the distance from the epiglottis to the midpoint of the distance between the vocal folds, (b) the depth of the pre-epiglottic space

After intravenous induction with midazolam 0.04 mg/kg, propofol 2–2.5 mg/kg, fentanyl 2μg/kg, and atracurium besylate 0.5 mg/kg, endotracheal intubation was carried out by anesthesia providers with a minimum of 2 years experience in endotracheal intubation with the patient in a neutral position without neck overextension or over-bending. The Macintosh blades were used to expose the target larynx, and no external laryngeal pressure was used to facilitate this process. Classification of laryngoscopic views was based on the method described by Cormack and Lehane.[2] Grade I is full view of the glottis. Grade II is a partial view of the glottis or arytenoids. Grade III is the only epiglottis seen. Grade IV is neither glottis nor epiglottis visible. Grade I and II are categorized as easy laryngoscopy. Grade III or IV are categorized as difficult laryngoscopy.

Real-time tracheal ultrasonography was performed during the intubation with the transducer placed transversely just above the suprasternal notch, to assess for endotracheal tube positioning and exclude esophageal intubation. The position of trachea was identified by a hyperechoic air-mucosa (A-M) interface with posterior reverberation artifact (comet-tail artifact). The endotracheal tube position was considered as endotracheal if single A-M interface with comet-tail artifact was observed. Endotracheal tube position was defined as intra-esophageal if a second AM interface appeared, suggesting a false second airway (double tract sign).

A standard protocol was followed for auscultation with the investigator first auscultating over the epigastrium, then in the right and left lung in that order. Unchanged $ETCO_2$ levels and capnography after six ventilations were regarded as final proof of endotracheal intubation. Time measurement was started when the laryngoscope blade was introduced into the mouth to confirmation of the tube placement by sonographically, auscultation and capnography.

Statistical analysis: Data were presented as frequency, percentages or mean ± SD, wherever applicable. Categorical variables between the groups were compared using Chi-square test. Quantitative variables between the groups were compared using student t-test. A P values less than 0.05 considered significant. Statistical analyses were performed using SPSS trial version 21.

Results

The present study was aimed to preoperative assess airway by the point of care USG in patients undergoing surgery under general anesthesia. The prospective observational study was conducted for a period of one year in Department of Anesthesiology, Dr. RPGMC, Kangra at Tanda, Himachal Pradesh. A total of 200 patients were included in the study after they fulfilled inclusion criteria.

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Table 1. Comparison of Different variables in different grades

	Cormack Lehane Grading (n=200)				P Value
	Easy (n=142)		Difficult (n=58)		
	Grade 1 (n=54)	Grade 2 (n=88)	Grade 3 (n=49)	Grade 4 (n=9)	
HMDN (cm)	5.52±.366	5.48±.349	5.64±.431	5.41±.421	P^{1234}=0.072
HMDE (cm)	6.19±.395	6.12±.379	6.14±.475	5.71±.438	P^{1234}=0.014 P^{14}= 0.007 P^{24}=0.023 P^{34}=0.023
HMDR (cm)	1.12±.033	1.11±.035	1.10±.127	1.04±.018	P^{1234}=0.010 P^{14}= 0.007 P^{24}=0.010
DSHB (cm)	.837±.162	.850±.171	.976±.23	1.15±.18	P^{1234}=0.000 P^{14}= 0.001 P^{23}=0.001 P^{24}=0.000
DSEM (cm)	1.42±.329	1.46±.358	1.89±.357	1.96±.211	P^{1234}=0.000 P^{14}= 0.000 P^{23}=0.000 P^{24}=0.000 P^{12}=0.000
DSAC (cm)	.89±.08	.92±.118	.960±.144	1.08±.122	P^{1234}=0.000 P^{13}= 0.038 P^{24}=0.001 P^{14}=0.000 P^{34}=0.022
Pre E/E-VC ratio	1.22±.439	1.56±.27	1.91±.25	2.25±.31	P^{1234}=0.000 P^{12}= 0.000 P^{24}=0.000 P^{14}=0.000 P^{34}=0.000
Time by Auscultation(s)	36.31±.577	36.65±.607	40.24±.902	41.67±.866	P^{1234}=0.000
Time by USG(s)	29.17±.575	29.56±.564	32.65±1.032	33.78±1.202	P^{1234}=0.000
Time by Capnography (s)	37.31±.577	37.65±.607	41.24±.902	42.67±.866	P^{1234}=0.000

The present study found that there was a significant difference (P=0.072) in HMDN of the patients in grade 1 (5.52±.366), grade 2 (5.48±.349), grade 3 (5.64±.431), and grade 4 (5.41±.421). HMDE was significantly different (P=0.014) in grade 1 (6.19±.395), grade 2 (6.12±.379), grade 3 (6.14±.475), and grade 4 (5.71±.438) (fig 12). We also found a significant difference in HMDE between grade 1 and 4 (P=0.007), grade 2 and 4 (P=0.023), and grade 3 and 4 (P=0.023). Pre E/E-VC ratio was significantly different (P=0.000) when Cormack Lehane grade 1 (1.22±.439), grade 2 (1.56±.27), grade 3 (1.91±.25), and grade 4 (2.25±.31) (fig 17). There was also found a significant difference in Pre E/E-VC ratio in grade 1 and 2 (P=0.000), between grade 2 and 4 (P=0.000), between grade 1 and

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4 (P=0.000) and between grade 3 and 4 (P=0.000). In this present study, it was found that there was a significant difference in time taken by USG in seconds for confirmation of endotracheal intubation (P=0.000) of the patients in grade 1 (29.17±.575), grade 2 (29.56±.564), grade 3 (32.65±1.032), and grade 4 (33.78±1.202)

Table 2. Diagnostic Values of USG parameters with Intubation

	DSHB	DSEM	DSAC	Pre E/E-VC
Sensitivity	48.28%	89.66%	60.34%	82.76%
Specificity	82.39%	64.79%	61.97%	83.80%
Positive Predictive Value	52.83%	50.98%	39.33%	67.61%
Negative Predictive Value	79.59%	93.88%	79.28%	92.25%
Area Under Curve (AUC)	0.68	0.819	0.628	0.871
Confidence Interval	0.594-0.767	0.755-0.880	0.536-0.718	0.820-923
P Value	0.000	0.000	0.005	0.000

We also calculated diagnostic values of DSHB with intubation. We found that sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of DSHB with intubation was 48.28%, 82.39%, 52.83, and 79.59. The area under the curve (AUC) was found to be 0.680 which was significant (P=0.000). We found that sensitivity, specificity, PPV, and NPV of DSEM with intubation was 89.66%, 64.79%, 50.98, and 93.88. AUC was found to be 0.819 which was highly significant (P=0.000). We found that sensitivity, specificity, PPV, and NPV of Pre E/E-VC Ratio with intubation was 82.76%, 83.80%, 67.61%, and 92.25%. AUC was found to be 0.871 which was highly significant (P=0.000).

Discussion

There are several traditional indices of predicting difficult laryngoscopy, but none of them is 100% sensitive and specific. Ultrasound is a new addition to the anesthesiologist's armamentarium, which has revolutionized care in several areas. The role of ultrasound in airway assessment is still primitive, with no established standard parameters to predict a difficult laryngoscopy. The present study was designed to establish a correlation between preoperative sonographically assessed parameters and the grade of difficulty at direct laryngoscopy.

There have been number of clinical methods and technical aids which have been described to confirm the endotracheal intubation. End-tidal capnography and auscultation remain the most used technical aids to confirm the endotracheal intubation. Viewing the tube passing between the cords during direct laryngoscopy and visualization of the tracheal rings and carina with a fiberoptic scope after intubation is the only full proof methods of confirming tracheal intubation.

A study done by Thomas et al to find the effectiveness of tracheal ultrasonography to confirm ETT placement with the existing methods. It was concluded that Ultrasonography, end-tidal capnography, and conventional clinical methods have comparable sensitivity and specificity in identifying the tracheal or esophageal position of ETT. The time taken to confirm tube placement with ultrasonography was 8.27 ± 1.54 s compared to waveform capnography and clinical methods which were 18.06 ± 2.58 and 20.72 ± 3.21 s, respectively. The time taken by ultrasonography was significantly less. Hence, ultrasonography detected the tube placement faster than the other two methods. The

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difference between results can be due to the reason that in the study by Thomas et al the time measurement was started when the person who did the intubation confirmed the completion of intubation while in the present study time measurement was started after the introduction of laryngoscopic blade in the mouth.[4]

Pfeiffer et al[5] performed a prospective, paired and investigator-blinded study performed in the operating theatre. No significant difference was found between the US compared with auscultation alone. The median time for verification by auscultation alone was 47.5s with a mean difference of -0.3s in favor of US. Comparing the US with the combination of auscultation and capnography, there was a significant difference between the two methods. The median time for verification by the US was 43 vs. 55s, ($P<0.0001$). The difference between results can be due to the fact in the study by Pfeiffer et al confirmation of endotracheal intubation by ultrasound was done by lung sliding sign while in the present study the endotracheal tube confirmation was done by real-time ultrasonography by keeping ultrasound probe in suprasternal notch.

So, ultrasound is better and fast in confirming endotracheal intubation as compared to auscultation and capnography. This is important in situations where time is critical.

There are a few limitations of this study. Patients with BMI >30 kg/m² were not included in this study. This drawback warrants further studies involving patient groups having factors associated with difficult intubation such as pregnancy, obesity etc. Secondly, the inter-subject variability can be a limiting factor, particularly in relation to ultrasound-guided HMDR. Third , the difficult laryngoscopy not necessarily correlates with difficult intubation, and external laryngeal manipulation tends to facilitate intubation most of the times.

Conclusion

Ultrasound is better and fast than other method for endotracheal intubation

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