A PROSPECTIVE OBSERVATIONAL STUDY TO DETERMINE THE USEFULNESS OF ULTRASOUND GUIDED AIRWAY ASSESSMENT PREOPERATIVELY IN PREDICTING DIFFICULT AIRWAY

ABSTRACT

Aim: The primary aim of this study was to assess the usefulness of ultra sonogram as a preoperative assessment tool in identifying difficult airway.

Methodology: 141 patients who were to undergo elective surgery under general anesthesia and required endotracheal intubation were included in the study. Preoperatively ultrasound guided airway assessment was done to measure the thickness of soft tissues in the anterior neck at three levels namely (a) Hyoid bone, (b) Thyrohyoid membrane and (c) Suprasternal notch. Two patients’ demographic details like age, sex, BMI were also recorded. On the day of surgery, the attending anesthesiologist provided anesthesia to the patient according to standard protocol. Direct laryngoscopy was done and the Cormack-Lehane grading of larynx was recorded.

Results: The statistic analysis tools that were used in this study for comparison between demographic variables, ultrasound measurements and Cormack-Lehane classification was independent t test and Chi square test. There was no statistical significance between the demographic variables like age, sex and BMI of the patients. The ultrasound measurements made at the three levels, (a) Hyoid bone, (b) Thyrohyoid membrane and (c) Suprasternal notch showed that increase in anterior neck soft tissue thickness correlates with the increasing difficulty of intubation. On Receiver Operating Characteristic curve (ROC) curve analysis, among the three levels, the measurement made at thyrohyoid membrane level (skin to epiglottis thickness) was found to be highly sensitive (88.9%) and specific (88.6%). A cutoff point of 2.08cm was found to delineate easy and difficult airway.

Conclusion: Based on this study we concluded that ultrasound can be used as a reliable tool to identify difficult airway by measuring the thickness of soft tissues in the anterior part of neck. We found that there is significant correlation between the thickness of soft tissue at the thyrohyoid membrane level and difficulty in intubation.

INTRODUCTION:

The fundamental responsibility of an anesthesiologist is to ensure adequate oxygenation during surgical procedure. Failure to maintain a proper airway for more than five minutes results in brain damage or death. In the 1990s, closed claims analysis showed that 85% of respiratory event-related malpractice claims involved a brain damaged or dead patient. 1 In any patient the greater the difficulty in maintaining the airway, the greater the risk of brain damage or death.

The ASA Task force defined “difficult mask ventilation” as occurring when:

1. It is not possible for an unassisted anesthesiologist to maintain the SPO2> 90% using 100% oxygen and positive pressure mask ventilation in a patient whose SPO2 was > 90% before anesthetic intervention; and/or

2. It is not possible for an unassisted anesthesiologist to prevent or reverse signs of inadequate ventilation during positive pressure mask ventilation.

And “difficult endotracheal intubation” as occurring when proper insertion of the tracheal tube with conventional laryngoscopy requires more than three attempts or more than 10 minutes.

Identification of difficult airway before manipulation is the Holy Grail of clinical management. Selection of airway devices and techniques all pivot on airway evaluation. A few risk factors for difficult mask ventilation include massive jaw, edentulous patients, obesity, history obstructive sleep apnea, burns, inadequate mouth opening etc. But many of the abnormalities cannot be diagnosed by classic airway examination techniques.

The usual scores used for airway evaluation are Mallampati or Samsoom classification, where oropharynx is divided into four grades on the basis of structures visualised after opening the mouth. Higher the Mallampati score difficult the mask ventilation. Thyromental distance is another predictor used for detecting difficult airway. Normal is thyromental distance is 6.5cm. A thyromental distance of 6 cm or less is predictive of difficult intubation. Interincisor gap or adequate mouth opening ensures easy intubation. Inability to translate the temperomandibular joint is an indicator of difficult intubation. Similarly cervical vertebral range of motion also predicts difficulty of airway management.

It has been seen that many a times airway evaluation falls short of intended goal. Of late ultrasound is gaining popularity as a non invasive painless modality for airway assessment. Preoperatively anesthesiologist does the ultrasound examination of the airway at the level of Hyoid bone, at the level of Thyrohyoid membrane and at the level of Suprasternal notch to predict difficult intubation. Various studies have shown that increase in thickness of soft tissue in anterior neck region correlates with increase difficulty in intubation.

The present study was designed to evaluate utility of ultrasound in airway assessment. An attempt has been made to find whether USG assessment can predict difficult airway.

ULTRASOUND ANATOMY OF AIRWAY

Kristensen et al (2013) has stated that “the linear high frequency transducer is most suitable for imaging superﬁcial airway structures (within 2-3 cm from the skin) and that the curved low-frequency transducer, is most suitable for obtaining sagittal and parasagittal views of structures in the submandibular and supraglottic regions, mainly because of its wider field of view.”

Ultra sonogram appearance of upper airway structures are as shown in figures 25,26,27,28,29.

ANATOMICAL PREDICTORS OF DIFFICULT AIRWAY

1. Mallampatti’s test:
The Mallampatti’s classification gives us the relationship between the size of the tongue and the size of the pharynx. The patient is seated, head held in neutral position, mouth open as wide as possible and tongue protruded out maximum. Patient should be...
MALLAMPATI CLASSIFICATION

In Samson and Young’s modification (1987) of the Mallampatti’s classification, a IV class was added.

Mallampatti’s I: Soft palate, faucets, uvula, anterior and the posterior pillars are visible.

Mallampatti’s II: Soft palate and faucets and uvula are seen.

Mallampatti’s III: Soft palate and base of uvula alone are seen.

Mallampatti’s IV: Only hard palate seen.

Atlanto occipital joint (AO) extension: Ability to maintain Sniffing or Magill position for intubation is assessed by this test. The patient is asked to hold head erect, facing directly to the front, then he is asked to extend the head maximally and the examiner estimates the angle traversed by the occlusal surface of upper teeth. Measurement can be by simple visual estimate or more accurately with a goniometer. Any reduction in extension is expressed in grades:

Grade I: >35°
Grade II: 22°-34°
Grade III: 12°-21°
Grade IV: < 12°

Normal angle of extension is 35° or more.

Mandibular space

THYROMENTAL (T-M) DISTANCE (PATIL’S TEST): Thyromental distance as the name suggests is the distance between the thyroid notch and tip of mentum. It is measured after asking the patient to keep the neck fully extended. Thyromental distance gives a rough idea of the relation between larynx and pharynx. It gives us information regarding the alignment of each other when the neck is placed in the intubating position.

- Difficult intubation - distance is < 6 cm in adults;
- Less difficult intubation - 6 - 6.5 cms
- Easy intubation - > 6.5 cm

STERNO-MENTAL DISTANCE: Sterno mental distance is the distance between suprasternal notch and tip of mentum. It is measured after asking the patient to keep the neck fully extended. Sterno mental distance < 12cms - intubation difficult.

Mandibulo-hyoid distance: Distance from tip of mandible to hyoid bone is called mandibulo hyoid distance. If the distance is increased then intubation is difficult. Normal is <4 cms.

Inter-incisor distance: The vertical distance from upper incisor to lower incisors.

Normal is > 4 cm.

<4 cm - difficult airway.

Wilson’s scoring system:

<table>
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<tr>
<th>PARAMETER</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
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<tbody>
<tr>
<td>Weight (Kg)</td>
<td>&lt;90</td>
<td>90-110</td>
<td>&gt;110</td>
</tr>
<tr>
<td>Head and Neck movement</td>
<td>&gt;90 degree</td>
<td>=90</td>
<td>&lt;90</td>
</tr>
<tr>
<td>Inter incisor gap</td>
<td>&gt;5 cm</td>
<td>= 5cm</td>
<td>&lt;5 cms</td>
</tr>
<tr>
<td>Sliding mandible</td>
<td>&gt;0</td>
<td>&gt;0</td>
<td>&lt;0</td>
</tr>
<tr>
<td>beyond incisors</td>
<td>maxillary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receding mandible</td>
<td>None</td>
<td>Moderate</td>
<td>Severe</td>
</tr>
<tr>
<td>Buck tooth</td>
<td>None</td>
<td>Moderate</td>
<td>Severe</td>
</tr>
</tbody>
</table>

LEMON criteria:

<table>
<thead>
<tr>
<th>L</th>
<th>Look</th>
<th>Facial trauma</th>
<th>Large incisors</th>
<th>Large tongue</th>
<th>Beard or moustache</th>
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<tbody>
<tr>
<td>E</td>
<td>Evaluate</td>
<td>Incisor distance - 3 finger</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>Mallampatti’s</td>
<td>Score &gt; 3</td>
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<td></td>
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</tr>
<tr>
<td>O</td>
<td>Obstruction</td>
<td>Epiglottis</td>
<td>Peri-tonsillar abscess, Trauma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>Neck mobility</td>
<td>Limited</td>
<td></td>
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AIM OF THE STUDY

To assess the usefulness of ultrasound as a non invasive tool in assessing the airway

To assess the use of USG in identifying difficult airways.

MATERIALS AND METHODS

After obtaining approval from ethical committee and written informed consent a prospective observational study was carried out in 141 patients in Stanley medical college Hospital. Patients
The hyoid bone was identified as an inverted U-shaped hyperechoic structure in the submandibular region. The image was frozen on screen and measurement from skin to midpoint of hyoid bone was taken using the “measure” option in the ultrasound machine.

The Epiglottis was identified in the Thyrohyoid membrane level as a linear hypoechoic structure followed by a hyperechoic shadow. Measurement was taken from skin to epiglottis as mentioned previously.

Tracheal ring was identified in the suprasternal notch level, as a hyperechoic structure followed by acoustic shadowing of air mucosal interface. Measurements from skin to tracheal ring were obtained as mentioned previously.

Recording data: The collected data were recorded for further analysis. The patients were then taken back to their wards. The next day morning on the day of surgery the patients were shifted to their respective operating rooms and the standard general anesthesia procedure was performed as per the discretion of the attending anesthesiologist who had experience in the field of ANESTHESIOLOGY for at least a minimum of 5 years.

All patients were connected to monitors - ECG, NIBP and PULSE OXIMETER and any additional monitors required as per the type of surgical procedure were kept ready. All patients were premedicated, pre oxygenated, induced and paralyzed using drugs according to the choice of the attending anesthesiologist before intubation. A macintosh blade was used for laryngoscopy. The anesthesiologists were asked to grade the vocal cord view as per Cormack Lehane grading. The best views obtained at the first attempt by the laryngoscopy without any external maneuver were applied as taken as the Cormack Lehane classification.

Cormack Lehane class 1 - visualization of the entire laryngeal aperture

Cormack Lehane class 2 - visualization of parts of the laryngeal aperture or the arytenoids

Cormack Lehane class 3 - visualization of only the epiglottis

Cormack Lehane class 4 - visualization of only the soft palate.

The surgery was carried out and after surgery was over the patients were reversed and extubated. They were observed for half an hour post operatively for full recovery and then the patients were shifted to the post operative wards for further management.

Groups
Based on the Cormack Lehane (CL) class noted, patients were grouped into two groups.

Group 1: Easy laryngoscopy group (CL 1 and CL 2)
Group 2: Difficult laryngoscopy group (CL 3 and CL 4)

Statistical analysis
To allow for comparisons between the difficult airway and easy airway groups, a two-sided Student’s t-test was used.

ROC curve analysis was made for all three levels for obtaining cutoff points that delineates the Group E from Group D, and to assess for the sensitivity and specificity for each measured level.

Association between demographic variables and occurrence of difficult intubation was assessed using Pearson’s chi square test. p < 0.05 was considered significant and p > 0.05 was not significant.

RESULTS
For the present study sample size of 141 was determined by power analysis using SPSS package version 8. The analysis report is shown in graph 1.

\textbf{GRAPH 1}

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\textbf{t tests - Means: Difference between two independent means (two groups)}

\textbf{Analysis: A priori: Compute required sample size}

\textbf{Input:}
- Tail(s) = Two
- Effect size d = 0.555
- \( \alpha \) err prob = 0.05
- Power (1-\( \beta \) err prob) = 0.90

\textbf{Allocation ratio N2/N1 = 1}

\textbf{Output:}
- Noncentrality parameter \( \delta \) = 3.2834243
- Critical t = 1.9773035
- Df = 138

\textbf{Total sample size = 140}

\textbf{Actual power = 0.9032896}

\textbf{GROUPING OF CASES}

Based on the CL grading, 141 patients under the study were classified into 2 groups.

- Group E (Easy airway)
- Group D (Difficult airway)

Of the 141 patients 132 are classified into group E and the rest 9 patients were classified in group D.

The observations and results were as follows

\textbf{AGE DISTRIBUTION}

The mean values of age of patients in easy and difficult intubation is shown in Table 1 (Group E and Group D)

\textbf{TABLE 3}

<table>
<thead>
<tr>
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<th>NO</th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUP E</td>
<td>132</td>
<td>38.73</td>
<td>13.004</td>
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<tr>
<td>GROUP D</td>
<td>9</td>
<td>46.33</td>
<td>10.025</td>
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P value = 0.088

P value > 0.05 is not significant

Out of the total 141 cases, the mean age in group E (N = 132) was 38.73 years and the standard deviation was 13.004. Mean age in Group D was 46.33 and the standard deviation was 10.025. These data were computed using students t-test and the P value was be 0.088 which is not statistically significant.

\textbf{SEX DISTRIBUTION}

\textbf{TABLE 4}

<table>
<thead>
<tr>
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<th>GROUP E</th>
<th>GROUP D</th>
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<tbody>
<tr>
<td>FEMALE</td>
<td>81</td>
<td>7</td>
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<tr>
<td>MALE</td>
<td>51</td>
<td>2</td>
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P value = 0.82

P value > 0.05 is not significant

Out of the total 141 case, 88 cases were females and 53 cases were males. Of the 88 female cases, 81 belonged to Group E and 7 belonged to Group D and out of 53 male cases, 51 belonged to Group E and 2 belonged to Group D. These data were computed using Pearson’s Chi Square test and the P value is found to be 0.82, which is not statistically significant.

\textbf{Conclusion: Thus, we conclude that Sex distribution is not significant}

\textbf{BMI DISTRIBUTION}

\textbf{TABLE 5}

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<th>NO</th>
<th>MEAN</th>
<th>SD</th>
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<tr>
<td>GROUP E</td>
<td>132</td>
<td>23.7</td>
<td>2.2</td>
</tr>
<tr>
<td>GROUP D</td>
<td>9</td>
<td>24</td>
<td>2.46</td>
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</table>

P Value- 0.779

P Value <0 .05 significant

Out of 141 cases in our study, 132 belongs to easy airway group (GROUP E) and 9 cases belongs to difficult airway group(GROUP D). The mean BMI distribution in Group E is 23.7 with standard deviation of 2.197 and the mean BMI distribution in Group D is 24 with standard deviation of 2.466. By using independent t test, the P Value was found to be 0.779 which is statistically not significant.

\textbf{Conclusion : Thus, we conclude that BMI distribution is statistically not significant}
THICKNESS OF ANTERIOR NECK SOFT TISSUE FROM SKIN TO HYOID

TABLE 6

<table>
<thead>
<tr>
<th></th>
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<th>MEAN</th>
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<tbody>
<tr>
<td>GROUP E</td>
<td>132</td>
<td>0.75</td>
<td>0.15</td>
</tr>
<tr>
<td>GROUP D</td>
<td>9</td>
<td>0.89</td>
<td>0.25</td>
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P value = 0.088
P value > 0.05 is not significant

GRAPH 5

Out of 132 cases in Group E, the mean value thickness of anterior neck soft tissue from skin to hyoid bone is 0.75±0.15. Out of 9 cases in Group D, the mean value thickness from skin to hyoid bone is 0.89±0.25. By using independent T test from statistical analysis, the P value was calculated to be 0.088.

Conclusion: There is no statistically significant difference in the thickness of anterior neck soft tissue at the level of hyoid bone.

THICKNESS OF ANTERIOR NECK SOFT TISSUE FROM SKIN TO EPIGLOTTIS AT THYROHYOID MEMBRANE LEVEL

TABLE 7

<table>
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<tr>
<th></th>
<th>NO</th>
<th>MEAN</th>
<th>SD</th>
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<tr>
<td>GROUP E</td>
<td>132</td>
<td>1.74</td>
<td>0.26</td>
</tr>
<tr>
<td>GROUP D</td>
<td>9</td>
<td>2.38</td>
<td>0.32</td>
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</table>

P value = 0.00
P value < 0.05 is significant

GRAPH 6

Out of 132 cases in Group E, the mean value thickness of the anterior neck soft tissue from skin to epiglottis at thyrohyoid membrane level is 1.74±0.26 standard deviation. Out of 9 cases in Group D, the mean value thickness from skin to epiglottis at thyrohyoid membrane level is 2.38±0.3126. By using independent T test for statistical analysis, the P value was calculated to be 0.00 which is highly significant.

Conclusion: There is statistically significant difference in the thickness of anterior neck soft tissue at the level of epiglottis in easy and difficult groups.

THICKNESS FROM ANTERIOR NECK SOFT TISSUE FROM SKIN TO TRACHEAL RING AT SUPRASTERNAL NOTCH LEVEL

TABLE 8

<table>
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<th></th>
<th>NO</th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROUP E</td>
<td>132</td>
<td>0.73</td>
<td>0.126</td>
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<tr>
<td>GROUP D</td>
<td>9</td>
<td>1.03</td>
<td>0.536</td>
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</table>

P value = 0.128
P value < 0.05 is significant

GRAPH 7

Out of 132 cases in Group E, the mean value thickness of the anterior neck soft tissue from skin to tracheal ring at suprasternal notch level is 0.73±0.1237. Out of the 9 cases in Group D, the mean thickness from skin to tracheal ring at suprasternal notch level is 1.03±0.5362 standard deviation.

By using independent T test for statistical analysis, the P value was calculated 0.128, which is statistically not significant.

Conclusion: There is no statistically significant difference in the thickness of anterior neck soft tissue at the level of suprasternal notch in easy and difficult groups.

ROC CURVE ANALYSIS FOR CUT OFF POINTS

ANTERIOR NECK SOFT TISSUE THICKNESS FROM SKIN TO HYOID

BONE LEVEL
Based on ROC curve the cutoff point that delineates the Group E and Group D for hyoid level is 0.78 cms. And area under the curve is 0.722.

Out of the total 141 cases in the study the number of cases above the cutoff point is 53 and the number of cases less than the cutoff point is 88. This states that based on the Cutoff point of hyoid bone, 53 cases are predicted to be difficult intubation but based on Cormack Lehane grading, only 9 cases were categorized as Group D. Similarly 88 cases were predicted as Easy intubation group based on cutoff point by hyoid bone. But based on Cormack Lehane grading 132 cases belonged to Group E.

Based on these data the sensitivity and specificity were calculated for Anterior neck soft tissue thickness at hyoid level.

Cutoff point is 0.78

Area under the curve is 0.722 Sensitivity is 66.7% sensitive. Specificity is 66.7% specific.

THICKNESS OF ANTERIOR NECK SOFT TISSUE FROM SKIN TO EPIGLOTTIS AT THYROHYOID MEMBRANE LEVEL

Based on ROC curve the cutoff point that delineates the Group E and Group D for thyrohyoid membrane level is 2.08cms. Area under the curve is 0.889.

Out of the total 141 cases in the study the number of cases above the cutoff point is 24 and the number of cases less than the cutoff point is 117. This states that based on the Cutoff point of hyoid bone, 24 cases are predicted to be difficult intubation but based on Cormack Lehane grading, only 9 cases were categorized as Group D.

Similarly 117 cases were predicted as Easy intubation group based on cutoff point by hyoid bone. But based on Cormack Lehane grading 132 cases belonged to Group E.

Based on these data the sensitivity and specificity were calculated for Anterior neck soft tissue thickness at Thyrohyoid membrane level (Epiglottis level).

Cutoff point is 2.08cms

Area under the curve is 0.929 Sensitivity is 88.9% sensitive. Specificity is 88.6% specific.

THICKNESS OF ANTERIOR NECK SOFT TISSUE FROM SKIN TO TRACHEA

RING AT SUPRASTERNAL NOTCH LEVEL

REFERENCES:


57. Lakhal K et al. The feasibility of ultrasound to assess sub glottic diameter. Anesth Analg 2007; 104:611-4