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Correlation between preoperative ultrasonographic airway assessment and laryngoscopic view in adult elective surgical patients: A prospective observational study

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Abstract

Background: Difficult intubation is associated with serious morbidity and mortality and cannot be always predicted by conventional clinical predictors. Ultrasonographic airway assessment could be a useful predictor of difficult airway and it thus correlates with various clinical and laryngoscopic view of airway which is the Cormack- Lehane grading.

Aims and Objectives: To find out the correlation between ultrasonographic airway assessment and clinical airway assessment for difficult airway prediction and to compare the results with Cormack-Lehane grading during intubation.

Materials and Methods: The study population includes 155 adult patients undergoing elective surgery under general anaesthesia. This is a prospective observational study where both the clinical airway assessment parameters and ultrasonographic parameters are noted and correlated. In clinical assessment- Modified Mallampati class, Mouth Opening, Thyromental Distance in flexion, Thyromental Distance in full extension, Neck Circumference, Neck Extension angle were assessed. In ultrasonographic parameters- Skin to hyoid distance, Skin to epiglottis distance, Anteroposterior thickness of the geniohyoid muscle. The anterior neck soft tissue thickness at the level of hyoid and vocal cord were assessed. All these parameters were compared with Cormack- Lehane grading.

Results: Among the clinical parameters**,** Mallampati classification has maximum sensitivity and specificity. And among the ultrasonographic parameters ANS-VC has maximum sensitivity of 95.1% and sensitivity of 85.7% and is significant. PRE-E, E-VC, PRE-E/E-VC is also significant with p value of <0.001. Hence, it correlates with CL grade. ANS-hyoid is not statistically significant.

Conclusion: Ultrasonographic measurement of anterior neck soft tissue- Vocal cord is an excellent predictor of difficult intubation. The most sensitive parameter compared to other clinical parameters. Measurement of Anterior neck soft tissue-Hyoid is not a useful indicator in predicting difficult intubation.

Keywords: airway assessment, clinical assessment, ultrasonography, cormack-lehane

Introduction

Unanticipated difficult intubation is the most challenging task an anaesthesiologist has to face [1]. Failure in managing a difficult intubation is one of the main causes of anaesthesia related mortality and morbidity [2] the incidence of operating (OR) difficult intubation is 1-18% [3] thus accurate prediction of difficult laryngoscopy is important in anaesthesia practice.

Several studies are conducted on prediction of difficult laryngoscopy using either single anatomical landmarks or multifactorial indices [4, 5, 6, 7] but no single landmark is accurate in predicting difficult laryngoscopy. Later studies attempted to predict difficult intubation based on several scoring systems like Wilsons score. The methods are quickly and easily preformed at the bedside, but unfortunately, their sensitivity and specificity for accurate prediction of difficulty with airway management is not the best.

The rationale for the use of ultrasonography (USG) for assessment of tissues in close proximity to the larynx is based on the observation of the process of direct laryngoscopy. Ultrasound has been evolving as a useful device for airway assessment [8], and sublingual ultrasound has been used for this purpose [9].The ability to visualize the hyoid through sublingual ultrasound has been recently shown to be an objective modality for predicting difficult laryngoscopic view [10] The present study was conducted to assess the usefulness of various ultrasonographic parameters in predicting difficult laryngoscopy.

Methods

Objectives of this study

1. To evaluate the efficacy of ultrasound guided airway parameters as a predictor of difficult laryngoscopy in adult surgical patients.
2. Comparison of ultrasound guided airway parameters with other anatomical parameters in prediction of difficult laryngoscopy.

Methodology

With the approval of the Institutional Ethical Committee, all patients will receive oral premedication with tab. pantoprazole 40mg and tab. alprazolam 0.5mg the night before surgery

After receiving the patient in pre anaesthesia room, weight, height, and Body Mass Index of the patient will be recorded. Patients having BMI>35 will be excluded from the study. Baseline readings of pulse rate, blood pressure and oxygen saturation of the patient will be recorded. Patient will be explained about the procedure and informed consent will be taken.

After obtaining the signed informed consent from the patient the following anatomical markers are measured.

Preoperative data recording: After ruling out any dental and airway pathologies-

1. Mouth opening (inter incisor distance): the patient will be made to sit in a chair with back well supported, asked to open the mouth as wide as possible and the distance between upper and lower incisors will be measured with a tape.
2. Modified Mallampati Score (MMPT): The patient in a sitting posture with the head in neutral position will be asked to open the mouth fully and protrude the tongue maximally without phonating. Grading:
   Class 1: soft palate, fauces, uvula, and pillars visible
   Class 2: soft palate, fauces, and uvula visible
   Class 3: soft palate and base of uvula visible
   Class 4: none of the soft palate visible
3. Thyromental distance (TMD): The patient will be seated upright and asked to extend his/her head and neck as far as possible with mouth closed. The straight distance of the exterior surface from the mentum to thyroid notch is measured. Also same measurement will be taken with head in neutral position.
4. Neck circumference: Neck circumference was measured in the upright and seated position at the level of the thyroid cartilage using a standard tape measure. Neck circumference of 43cm or greater was classified as predicting a difficult intubation [11]
5. Neck extension: Patient will be made to sit in a chair with shoulder and spine supported and asked to flex the neck completely. Then patient will be asked to extend the neck without moving his/ her shoulders. Angle will be measured with the help of a goniometer taking the plane from external auditory canal to tip of the nose.
6. Thyromental height: This is the height from anterior border of the thyroid cartilage and the anterior border of the mentum, with the patient lying supine with her/his mouth closed. Thyromental height less than 0.5cms will be considered as difficult intubation.

All the above measurements will be taken by a single person using a standard calibrated tape.

For sonographic assessment of the airway, the patient will be made to lie in the supine position with head in the neutral position without pillow, looking straight ahead with the mouth closed and the tongue on the floor of the mouth without any movement. The linear high frequency probe (L14-5/38, frequency 14-5MHz) of the ultrasound machine Mindray is used to measure the different ultrasonographic parameters. The probes will be placed on the skin under the patient's chin, at different levels, to get transverse view of the submandibular area and the upper part of the neck. Transverse view will be used for measuring the anteroposterior thickness of the geniohyoid muscle, the skin to hyoid, and the skin to epiglottis distance at the level of thyrohyoid membrane. Inside the operating room (OR) patient will be placed in a sniffing position with a standard size pillow below the head and all routine monitoring like ECG, pulse oximeter and NIBP is attached to the patient.

Induction will be done with a combination of fentanyl (1-2mcg/kg), and propofol (1.5-2mg/kg). Paralyzed with atracurium (0.5mg/kg) and then mask ventilation for 3mins and before laryngoscopy complete blockade with will be assessed with single twitch response using nerve stimulator.

The patients head will be placed in a sniffing position, and laryngoscopy will be performed using a Macintosh 4 blade or 3 blade.

Cormack lehane's grading

The view at laryngoscopy was graded by Cormack lehane's method in the following manner:

Grade I: Complete vocal cords visible

Grade IIa: visualization of posterior part of vocal cords

Grade IIb: only arytenoids are seen

Grade III: only epiglottis visible

Grade IV: none of the foregoing visible (not even the epiglottis).

Cormack Lehane grades I, II were defined as easy visualization of larynx (EVL) and predict easy intubation. Grades III and IV were defined as difficulty in visualization of larynx (DVL) and predict difficult intubation.

Sample size estimation

Formula used – $N= [Z\phi+Z\beta/C] 2+3$

Where $C= 0.5*\log [(1+r)/ (1-r)]$

N = 155

With the approval of the Institutional Ethical Committee and after obtaining informed consent, 155 patients coming for various elective surgeries under general anaesthesia requiring endotracheal intubation will be recruited for the study.

Inclusion Criteria

1. 18- 60years of age
2. ASA grade I and II.
3. Elective surgeries under general anaesthesia.

Exclusion Criteria

1. BMI>35
2. Neurological and musculoskeletal disorders.
3. Emergency surgeries requiring rapid sequence intubation.
4. Facial and neck abnormalities
5. Inability to sit up
6. Dental abnormalities.

Study design

It is a hospital based cross sectional study done from November 2018 to April 2020.

Method of randomisation

Prospective Observational study.

Statistical Analysis

Data is entered in MS Excel and analysis is done in SPSS Software version 20. Appropriate statistical tests were applied.

Results

One hundred and fifty five adult patients undergoing

elective surgery under general anaesthesia by endotracheal intubation are included in the study. The study included population aged between 18 to 60 years with 44.5% male patients and 55.5% female patients. The Body Mass Index of the study population ranged from 20.5 to 34.8kg/m^2. 41.3% of patients belonged to Cormack Lehane grade I. 40.6% of the patients belonged to Cormack Lehane grade II. 16.1 of the patients belonged to Cormack Lehane grade III and 1.9% of the population belonged to grade IV.

The distribution of Cormack Lehane grade was compared with the ultrasound parameters i.e., ANS-HYOID (Anterior neck soft tissue – at the level of hyoid), ANS-VC (Anterior neck soft tissue -vocal cord), PRE-E (Pre-epiglottic space), E-VC (Epiglottis to vocal distance), PRE-E/E-VC. The four groups in Cormack Lehane grade was analysed comparing with each of the parameters. The anterior neck soft tissue at hyoid level was not significant with p-value of 0.242 and hence it suggests that it does not correlate with Cormack-Lehane grading. The Anterior neck soft tissue at the vocal cord level was calculated and the analysis with Cormack Lehane grading suggests that is statistically significant with p value less than 0.001. Hence it correlates with Cormack Lehane grade. The distance from skin to epiglottis which is pre epiglottic space distance (p value< 0.001), epiglottis to vocal cord distance (E-VC p value <0.001) and the ratio of Pre-Epiglottic space and epiglottis to vocal cord is also statistically significant. Their ratio is also statistically significant. Hence these values are found to predict difficult intubation. The distribution of Cormack Lehane grading was compared to Mallampatti grading and Thyromental height. The analysis was statistically significant and thus it indicates that there is correlation between these parameters and CL grading. The sensitivity was defined here as true positivity that is it indicates that the parameter indicates difficult intubation and the CL grade also indicates difficult intubation (CL 2/3). The specificity -true negative is that the parameter indicates easy intubation and the CL grade is also suggestive of easy intubation (CL 1/2). Using this positive and negative predictive value was calculated. Using the sensitivity and specificity Receiver Operator Characteristic curve was drawn for MP grade, ANS-VC and Pre-E/E-VC.

Thus the statistical analysis showed that all the ultrasonography parameters ANS-VC, PRE-E, E-VC and PRE-E/E-VC were found to be significantly in correlating with the Cormack Lehane grading.

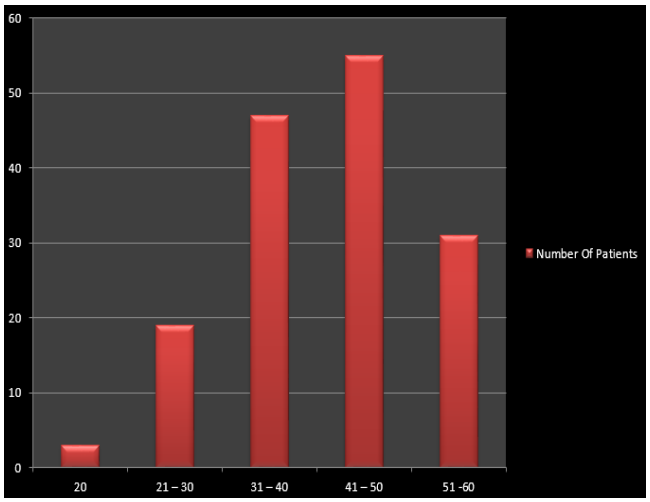

Fig 1: age distribution of the study population.

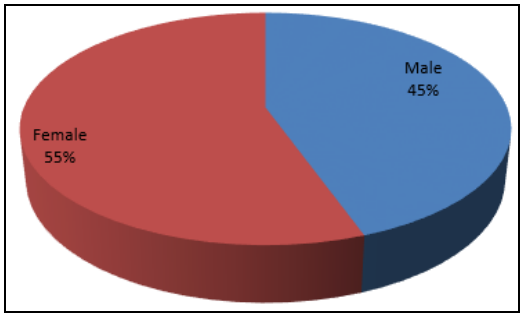

Fig 2: Gender Distribution of the Study Population

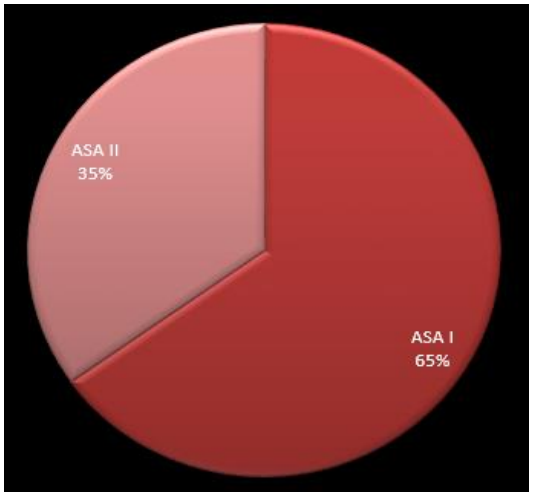

Fig 3: Distibution of Cases Based On Asa Classification

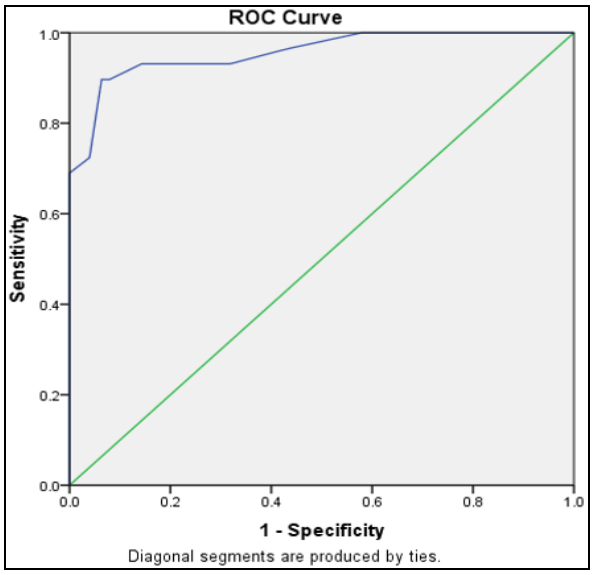

Fig 4: Roc Curve for Ans-Vc and Cl Grade

Table 1: comparision of ultrasonographic measurement (ans-vc) in predicting the cormack –lehane (cl) grade.

Variable	CL Grade			CL		AUC
	Sensitivity	1Specificity	Specificity	Lower Bound	Upper Bound	
ANSVC>2	95.1%	1-0.143	85.7	0.951	0.999	0.956

Table 2

Cut Value	Sensitivity	1-Specificity	Specificity
0.31	0.951	1-0.183	0.817
0.32	0.951	1-0.143	0.857

Table 3: Comparison of Ultrasound Parameter and Cormack –Lehane Cl Grade

Parameter	CL Grade	N	Mean ± S.D	P value
ANS -HYOID	1	64	0.365 ± 0.063	<0.0001Significant
	2	63	0.360 ± 0.077	
	3	25	0.388 ± 0.0506	
	4	3	0.383 ± 0.0321	
ANS -VC	1	64	0.272 ± 0.0341	<0.0001Significant
	2	63	0.254 ± 0.066	
	3	25	0.40 ± 0.050	
	4	3	0.386 ± 0.100	
PRE-E	1	64	0.947 ± 0.0749	0.0001 Highly Significant
	2	63	1.104 ± 0.105	
	3	25	1.027 ± 0.074	
	4	3	1.036 ± 0.0776	
E-VC	1	64	0.940 ±0.085	0.0001 Highly Significant
	2	63	0.870 ± 0.068	
	3	25	0.857 ± 0.0688	
	4	3	0.863 ±0.116	
PRE-E/E-VC	1	64	1.013 ± 0.105	0.0001 Highly Significant
	2	63	1.27 ± 0.139	
	3	25	1.201 ±0.132	
	4	3	1.21 ±0.124	

Table 4: Correlation between the Anatomical Parameter and Cormack –Lehane Cl Grade

Correlation	Pearson Correlation r Value	P Value
CL Grade Vs IIG in cm	-0.038	0.642 Not Significant
CL Grade Vs MP Class	0.361	<0.001Significant(p<0.001)
CL Grade Vs TMD	-0.118	0.481Not Significant
CL Grade Vs TMHT	-0.194	0.016 (week Correlation) Significant
CL Grade Vs Neck Circumference	0.021	0.754 Not Significant
CL Grade Vs Neck Extension	0.019	0.814 Not Significant

In our study when anatomical parameters and CL grade were correlated, IIG, TMD, Neck circumference and Neck extension showed no correlation and are statistically insignificant.

TMHT showed week correlation and are statistically significant with p-value of 0.016. MP class showed strong correlation with p value of <0.001.

Table 5: Correlation between the Ultrasound Parameter and Cormack –Lehane Cl Grade

Correlation	Pearson Correlation r Value	P Value
CL Grade Vs ANS -HYOID	0.095	0.242 Not Significant
CL Grade Vs ANS -VC	0.505	Significant (p<0.001)
CL Grade Vs PRE-E	0.374	<0.001 Significant
CL Grade Vs E-VC	-0.389	0.001 (negative Correlation) Significant
CL Grade Vs PRE-E/E-VC	0.230	0.004 Significant

In our study when ultrasound parameters are compared with CL grade, ANS-VC, PRE-E, E-VC, PRE-E/E-VC have strong correlation and are statistically significant. E-VC has negative correlation. ANS-HYOID not significant to compare according to our study.

Fig 5: Ultrasound Imaging Of Airway

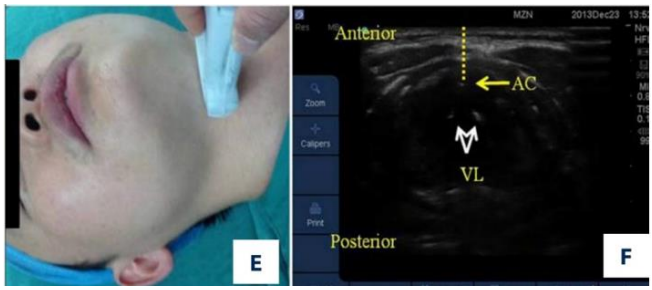

Fig 6: Anterior neck soft tissue at the level of vocal cords.

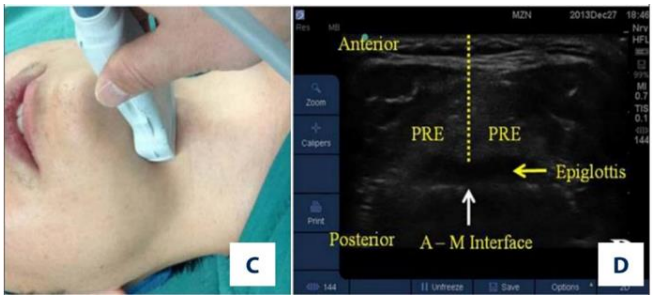

Fig 7: Skin to epiglottis distance

Discussion

There are several traditional indices of predicting difficult laryngoscopy, but none of them are 100% sensitive and specific. Ultrasound is a new addition to the anaesthesiologist'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. The parameters assessed by ultrasound, in our study, were the skin to hyoid distance, the anteroposterior thickness of the geniohyoid muscle, and the skin to epiglottis, epiglottis to vocal cord distance [13]

In my study, the anterior neck soft tissue-Vocal cord is a potential guide for assessing the airway and increased thickness had sensitivity of 95.1% and specificity of 85.7% in predicting the difficult intubation. The Pre epiglottis soft tissue thickness, Epiglottis to Vocal cord distance and ratio of the distances was found to be statistically significant. Hence this also predicted difficult intubation.

In my study the anterior neck soft tissue- HYOID distance was not statistically significant (p-value -0.242). Among clinical parameters in my study, the mallampati class, Thiopental height had a significant p-value for predicting the difficult intubation (CL 3/4).

Adhikari *et al*. [14] used ultrasound to determine the utility of monographic measurements of thickness of the tongue, anterior neck soft tissue at the level of hyoid bone, and the thyrohyoid membrane in distinguishing between easy and difficult laryngoscopy. They demonstrated that sonographer measurements of anterior neck soft tissue thickness at the level of hyoid bone and thyrohyoid membrane could be used to distinguish easy from difficult laryngoscopy.

In our study, we used the skin to hyoid and skin to epiglottis distance measurements at the level of the thyrohyoid membrane, as a measure of the anterior neck soft tissue and found anterior neck soft tissue at the level of vocal cords to be statistically significant.

Wu *et al*., [15] in their study on 203 patients, have shown that the thickness of the anterior neck soft tissue can be a predictor of difficult laryngoscopy. They found that the skin to hyoid distance as well as skin to epiglottis distance were good predictors of difficult laryngoscopy. In our study, the skin to hyoid distance had a lower sensitivity and specificity, when compared to skin to epiglottis distance, for prediction of difficult laryngoscopy.

Ezri *et al*. [16] measured the neck soft tissue distance from skin to anterior aspect of the trachea at the vocal cords, using ultrasound in fifty obese patients and found that patients with larger neck circumference and more pre tracheal soft tissue had difficult laryngoscopy. In our study, anterior neck soft tissue at the level of vocal cords was found to be significant.

Hui *et al*., have recently shown that visibility of hyoid bone on a sublingual ultrasound could be predictive of easy laryngoscopy. Their technique did not take much time to perform, and they showed that the inability to visualize the hyoid bone through a sublingual sonographic scan is predictive of a difficult laryngoscopy. One of the limitations of our technique was the time taken for complete airway assessment using ultrasound. In our study, the total time for preoperative airway assessment, to measure all the sonographic variables, was approximately 10 min in each patient. This is more time consuming compared to sublingual ultrasound technique described by Hui *et al*. However, our aim was to identify all possible variables which can be measured and find which had the maximum correlation with the laryngoscopic view.

Reddy, *et al*., conducted a study on 100 patients. According

to them the incidence of difficult intubation was 14%. An ANS-VC> 0.23 had a sensitivity of 85.7% in predicting a CL grade of 3 or 4, which was higher than Mallampati class. Specificity, PPV and accuracy were lower than the physical parameters. ANS-VC >0.23cm is a potential predictor of difficult intubation. ANS-HYOID is not indicative of difficult intubation. The ratio of Pre-E/E-VC is also significant. In our study, ANS-HYOID was not significant, ANS-VC of 0.31 as an indicator of difficult intubation with sensitivity of 93.1% and specificity of 85.7%. Pre epiglottic distance and Pre-E/E-VC were found to be significant.

In my study amongst all parameters, Anterior Neck Soft tissue- Vocal Cords distance had the highest sensitivity more than the clinical parameters. Negative predictive value was highest for anterior neck soft tissue- Vocal cord followed by Mallampati class. Pre-Epiglottis/Epiglottis-Vocal cord was useful in predicting difficult intubation. The clinical parameter Mallampati class has high specificity and negative predictive value.

Limitations

1. Only a few population had a BMI of more than 30kg/m^2. Hence if a study done including larger population with obese individuals, parameters would have been different and difficult to elicit.
2. Study did not include paediatric age group, population known to have difficult intubation.
3. Patients with dentition problems, facial abnormalities, and trauma were not included in the study.
4. We also did not assess the correlation between the volumes of tongue by ultrasound, as assessed with the modified Mallampati class. Mallampati classification is based on the space occupied by the tongue and use of ultrasound to calculate the exact volume of the tongue, and further research correlating this value with the Mallampati class could provide more information about a difficult laryngoscopy.

Conclusion

Our study showed that ultrasound can be used to assess the airway preoperatively, and several sonographic parameters can be measured. Ultasonographic measurement of the anterior neck soft tissue- Vocal cord is thus an excellent predictor of difficult intubation. Higher the value is the most sensitive physical parameter compared to other clinical parameters such as Mallampati class, Thyromental distance and Sternomental distance in predicting difficult intubation. ANS-HYOID was not useful in assessing difficult laryngoscopy. Exact value of these variables measured sonographically that would correlate with a difficult laryngoscopy needs to be established through future research.

Declaration of patient consent

The informed consent was obtained for participation in the study and publication of data and images for research and educational purpose

Funding

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Conflict of interest

None declared

Ethical approval

The study was approved by the Institutional Ethics Committee

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