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Comparison of Cuff Leak Test, Laryngeal Ultrasonography, and Videolaryngoscopy for the prediction of post-extubation stridor

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Abstract

Background and Aims
Post-extubation stridor (PES) leading to reintubation is a frequent complication of endotracheal intubation. This study was done to evaluate the sensitivity, specificity, predictive values, and diagnostic accuracy of the cuff leak test (CLT), laryngeal ultrasound (LUS), and videolaryngoscopy (VL) for the prediction of PES.
Material and Methods
This prospective, observational study was conducted on 80 adult patients intubated for at least 24 hours. Within 6 hours before extubation, CLT and LUS were done, with the endotracheal tube cuff inflated and deflated. Cuff leak volume (CLV), leak volume fraction ratio (LVFR), and airway column width difference (ACWD) were noted. The grade of peri-laryngeal edema was noted with VL. Statistical analysis was performed using the Chi-square test and Mann-Whitney U test.
Results
After extubation, patients were divided into two groups: PES (n=23, 28.8%) and non-PES (n=57, 71.25%). Reintubation rate was 100%, for those with PES, whereas the was no reintubation in those with no PES. CLV < 245 ml predicted the possibility of PES (P 0.001) with a sensitivity 91.3%, negative predictive value (NPV) 95.65%, specificity 77.19%, positive predictive value (PPV) 61.76%, and accuracy 81.25%. LVFR <28% predicted PES (P 0.001) with a sensitivity 65.22%, specificity 94.74%, PPV 83.3%, NPV 87.1%, accuracy 86.25%. ACWD <0.45 mm (P <0.003) predicted chances of PES with sensitivity 56.2%, specificity 78.95%, PPV 52%, NPV 81.82%, and accuracy 72.5%. VL scale > 2 predicted a significantly higher (P 0.001) risk of PES, (sensitivity 52.1%, specificity 92.98%, PPV 75%, NPV 82.81%, accuracy 81.25%).
Conclusions
An algorithmic approach should be adopted. All patients should undergo CLT before extubation. For patients with positive CLT, LVFR and videolaryngoscopy assessment should be done. ACWD should be used only in combination with other parameters.

Keywords: Cuff-leak, laryngeal ultrasound, videolaryngoscopy, post-extubation, stridor

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Introduction

Endotracheal intubation is an essential component in airway management or respiratory failure in critically ill patients. Mechanical pressure from the endotracheal tube (ET) may cause laryngeal edema. After extubation, airflow through the narrowed upper airway manifests as post-extubation stridor (PES). The incidence of post-extubation laryngeal edema (PELE), manifesting as respiratory distress or stridor, ranges from 4-37% in the ICU. [1] These patients may require reintubation, thus causing increased ICU morbidity and mortality. [1,2]

Prediction of airway patency is an integral part of extubation procedure. Various tests have been contemplated for assessment of laryngeal edema before extubation, of which cuff leak test (CLT) is the standard. It consists of assessing leak around the ET after balloon cuff deflation. Ample number of studies have been published on the CLT, but results are still contentious. [1-8] We used the quantitative method, as proposed by Miller et al. [9] We further subdivided into an absolute measure (measured in millilitre volume, i.e. cuff leak volume or CLV) and a relative measure (quantified as percent volume, i.e. leak volume fraction ratio or LVFR). The usual accepted values of CLV and LVFR are 110 ml and 10%. [9] We set the ventilator in Volume Control CMV mode, PEEP 5cm water and tidal volume (TV) 8ml/kg. Oral and endotracheal secretions were suctioned. Pre-set inspiratory TV and measured expiratory TV were noted with ET cuff inflated and deflated. The expiratory TV over next six breathing cycles was recorded with cuff deflated and average of lowest three was calculated. The difference between inspiratory TV with cuff inflated and averaged expiratory TV after cuff deflation is CLV. The LVFR was calculated as percentage ratio of average leak volume to inspiratory TV.

Recently, ultrasound has been used to visualize acoustic shadows at the level of vocal cords. Airway column width difference (ACWD), is then calculated to predict PES. [7,10–17] Videolaryngoscopy or fibreoptic laryngoscopy have also been used for visualization of peri-laryngeal structures and assessment of abnormalities. [7,18–20]

However, none of these tests have shown to be reliable and there is a considerable need to identify a test to confirm or exclude the presence of significant laryngeal edema before extubation. Hence, this study was conducted to determine the sensitivity, specificity, predictive values, and accuracy of the cuff leak test (CLT), laryngeal ultrasound (LUS), and video-laryngoscopy (VL) for the prediction of post-extubation laryngeal edema leading to reintubation. Our study had following objectives:

Primary Objective:
To evaluate diagnostic accuracy of CLT, LUS, and VL for prediction of PES.
Secondary Objectives:
- Post-extubation stridor rate
- Tracheal re-intubation rate

Methods

Study Design: This prospective observational study was conducted on 80 subjects admitted to the surgical, trauma, and medical ICUs of a tertiary care hospital, over 12 months, after approval from the Institutional Review Board and Ethical Committee and taking informed consent from the subject's first relative.

Inclusion criteria: Patients of both sexes who were intubated and mechanically ventilated for a minimum period of 24 hours and deemed ready for extubation were included in the study.

Exclusion criteria: Subjects with:
1. Age <18 years
2. Intubated for upper airway obstruction
3. Upper airway malignancy
4. Previous tracheostomy
5. Neck radiotherapy
6. Vocal cord paralysis

The following data was collected:
1. Demographic data: Age, gender, body mass index (BMI), co-morbidities like chronic kidney disease (CKD), diabetes-mellitus (DM), hypertension, chronic liver disease, hypothyroidism, opioid addiction, and stroke.
2. Data related to intubation: Endotracheal tube (ETT) size, cuff-pressure[20] using a pressure manometer, duration of intubation, traumatic intubation, elective or emergency intubation, done using direct or videolaryngoscopy.
3. Laboratory values: Serum albumin, cumulative fluid balance, Sequential Organ Function Assessment (SOFA) Score, Richmond Agitation Sedation Scale (RASS).
4. Occurrence of PES was confirmed by:
    a. The high-pitched sound after extubation.
    b. Respiratory distress within 24 hours of extubation.
    c. Accompanied with a respiratory rate >30/minute or increase by >10/minute from the baseline.

Study Protocol: Within 6 hours before planned extubation, CLT and real-time LUS were performed with ETT cuff inflated and deflated. VL was done to assess glottic and peri-glottic edema. Light sedation in increments of 25-50 mg of propofol was given to patients to suppress coughing, ventilator fighting, or active expiration.

Material and Methods

1.A. CLT:
The quantitative method, as proposed by Miller et al [9] was used. We further subdivided into an absolute measure (measured in millilitre volume, i.e. cuff leak volume or CLV) and a relative measure (quantified as percent volume, i.e. leak volume fraction ratio or LVFR).

Ventilator was set in Volume Control CMV mode, PEEP 5cm water and tidal volume (TV) 8ml/kg. Oral and endotracheal secretions were suctioned. Pre-set inspiratory TV and measured expiratory TV were noted with ET cuff inflated and deflated. The expiratory TV over next six breathing cycles was recorded and average of lowest three was calculated.
The difference between inspiratory TV with cuff inflated and averaged expiratory TV after cuff deflation is CLV.

1.B. LVFR:
It was calculated as percentage ratio of average leak volume to inspiratory TV.

2. Laryngeal Ultrasound:
Continuing same ventilator settings, patients were put in supine position with neck hyperextended and were examined with balloon cuff inflated and deflated. Vocal cords (VC) were visualized sonographically with linear probe (7-15 MHz), through anterior neck, at level of crico-thyroid membrane (figure-1) with transverse view of larynx. [10] Laryngeal air column width (ACW), width of air passing through vocal cords, was determined. The air column which was square shaped with balloon inflated, became trapezoidal after cuff deflation.

Air-column width difference (ACWD) is difference in ACW during balloon-cuff inflation and deflation. It was recorded for three consecutive times, and average value was recorded.

3. Videolaryngoscopy:
Continuing same settings, with patient sedated, the glottis and peri-glottic structures were visualized for any apparent edema or pathology, which if present, was classified according to the scale shown in Table No. 1. [22]
All patients were extubated by intensivists who were blinded for the test results. After extubation, patients were monitored for 48 hours for any signs and symptoms of respiratory distress or PES.

Statistics: Statistical analysis was performed using Student's t test, Mann-Whitney U test, chi-square test, and Fisher's exact test, wherever appropriate. Receiver operating characteristic (ROC) curve analysis was done to calculate the cut-off values, sensitivity, specificity, positive and negative predictive value (PPV and NPV), and diagnostic accuracy of CLT, laryngeal US, and videolaryngoscopy in predicting PES. A P value < 0.05 was considered statistically significant.

Results

Of the 80 patients enrolled, none required exclusion. Table 2 presents patient characteristics. The sample consisted predominantly of males (n = 54, 67.5%), with mean age of 47 ± 17 years. According to PES occurrence, the patients were divided into two groups: PES (n = 23, 28.8%) and non-PES (n = 57, 71.25%). Reintubation rate in PES patients was 100%.

There was no significant difference between both groups as regards age, sex, BMI, SOFA score, serum albumin, cumulative fluid balance, factors related to intubation and average RAAS score 24 hours before extubation. As regards co-morbidities, PES was significantly higher in patients with DM, hypertension, and CKD.

The mean values of CLT, LUS and VL parameters in both groups are presented in table 3. Mean CLV in our study was 305 ml ± 118 ml. However, in patients with PES, it was 117.65 ± 123.15 ml (Table 3). We found that CLV < 245 ml (Figure 3A) significantly predicted ($P < 0.001$) the possibility of PES with a high sensitivity (91.3%) and NPV (95.7%). The cut-off values, sensitivity, specificity, positive predictive value (PPV), negative predictive value and accuracy of all the parameters and their combinations, for the prediction of PES is presented in Table 4 and the ROC curves are represented in figure 3. LVFR cut-off < 28% had a very high specificity (94.74%), NPV (87.1%) and accuracy (86.3%). Combining CLT with LVFR, improved specificity 94.74%, NPV 90% and accuracy 88.75% of both (table 4, figure3A).

Mean and SDs for air column width (ACW) inflated (mm) in PES and non-PES groups were 3.9 ± 2.6 and 4.7 ± 3.3 respectively (P = 0.26). Mean and SDs ACW deflated (mm) in PES and non-PES groups were 3.2 ± 2.2 and 4 ± 2.9 respectively (P = 0.27). Mean ACWD (mm) in PES group was lower than non-PES group (0.61 ± 0.72 and 0.8 ± 0.5 respectively), although not statistically significant ($P = 0.174$) (table 3). Cut-off value of < 0.45 mm (figure 3C) was significantly ($P < 0.003$) predictive of higher chances of having PES but with a very low sensitivity (56.2%), specificity 79% and accuracy (72.5%) (table 4).

Videolaryngoscopy (VL) scale of > 2 was predictive of a significantly higher ($P = 0.001$) risk of having PES, with high specificity of 92.98%, NPV of 82.81% and accuracy of 81.25% (table 4, figure 3B).

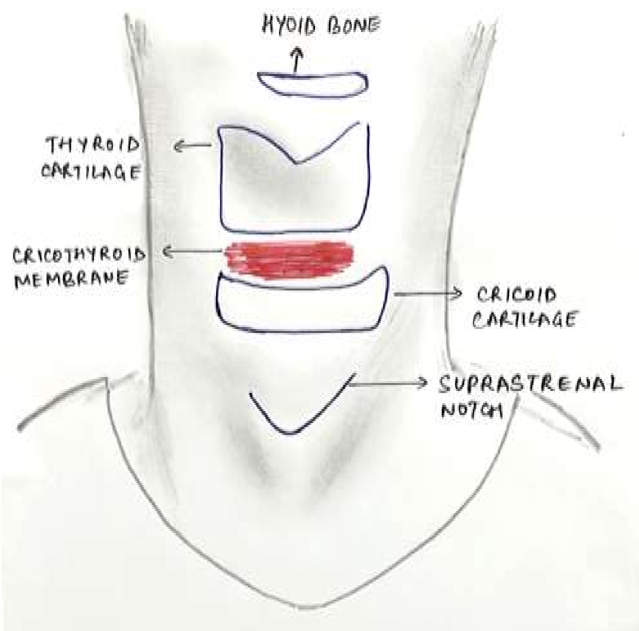


Figure 1A: Surface anatomy of neck showing cricothyroid membrane

Figure 1B: Position of the probe for a transverse view of the larynx

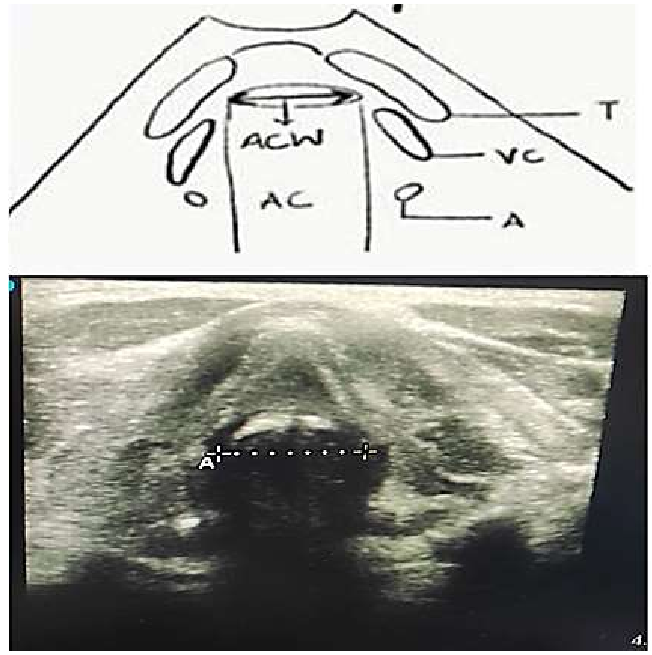


Figure 1C: ACWD (Airway Column Width Difference) with endotracheal tube cuff inflated
ACW=Airway Column Width
T= thyroid cartilage
VC= true vocal cords
AC= laryngeal air column
A=Arytenoid cartilage

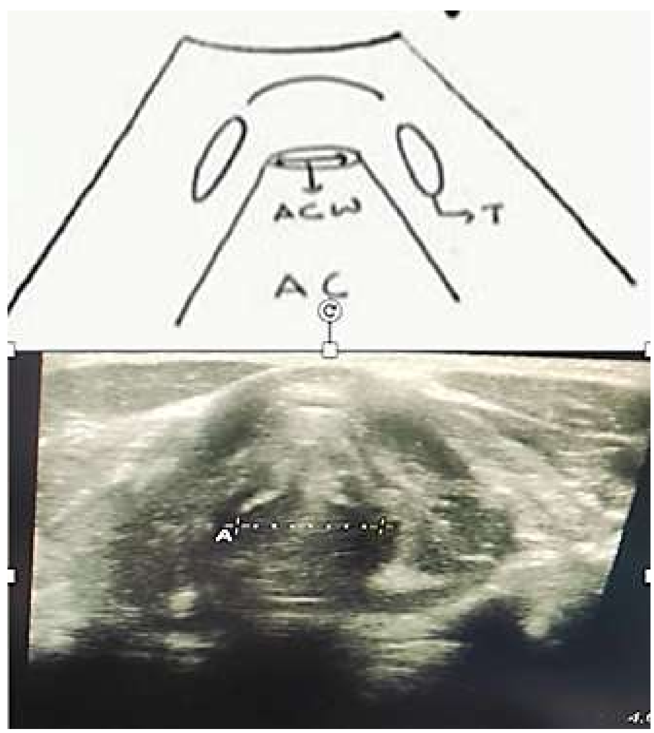


Figure 1D: ACWD (Airway Column Width Difference) with endotracheal tube cuff deflated
ACW=Airway Column Width
T= thyroid cartilage
AC= laryngeal air column

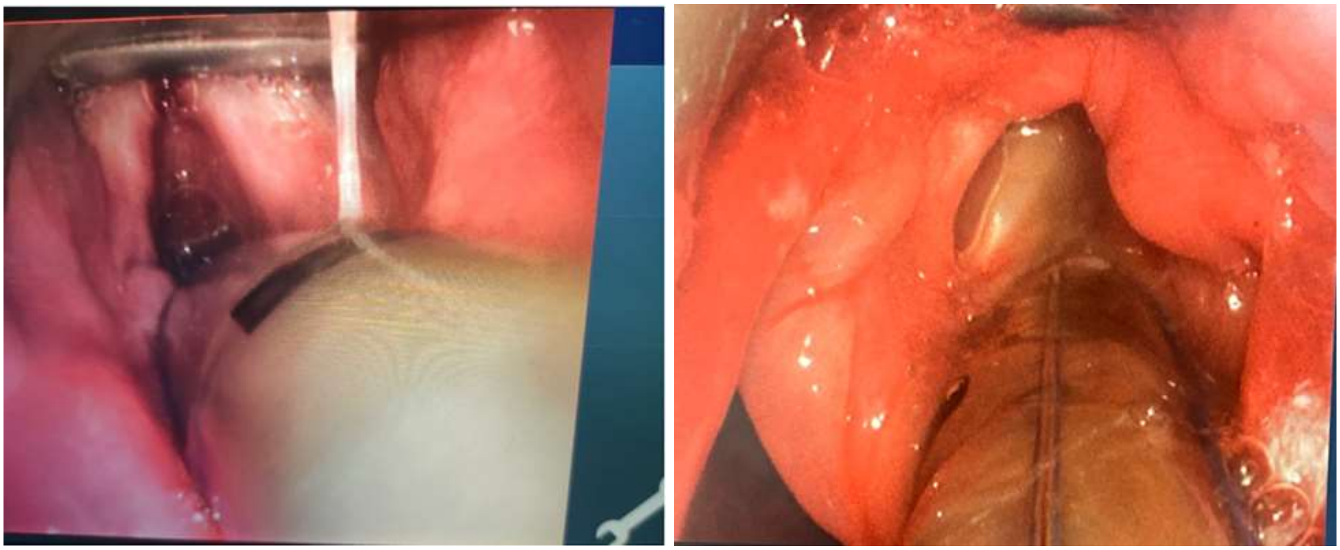
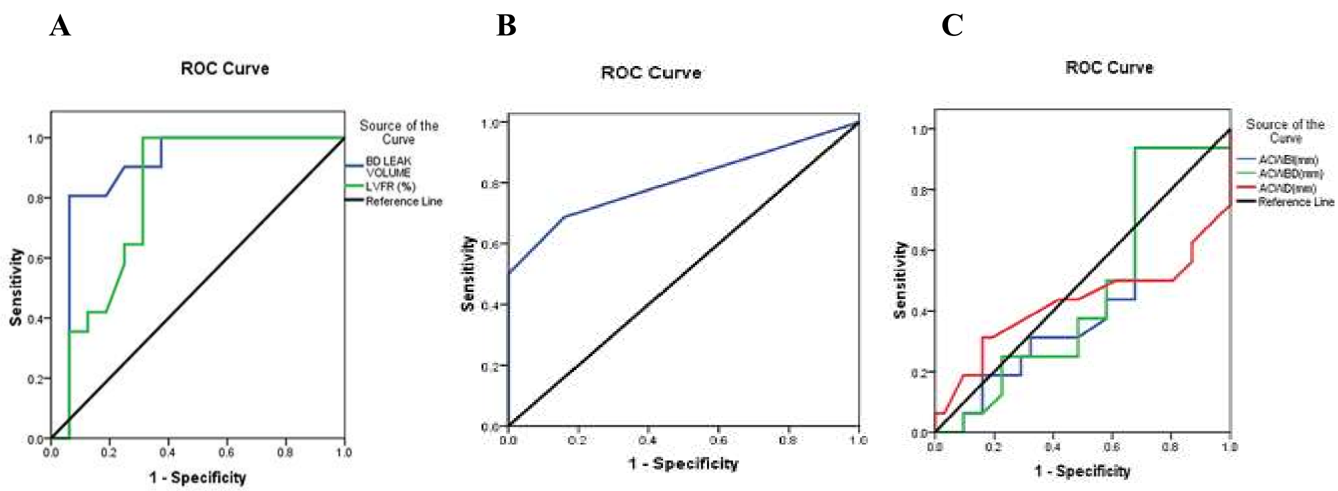


Figure 2: Left: Videolaryngoscopy image of a patient with no post-extubation stridor. Right: Videolaryngoscopy image of a patient with post-extubation stridor.



Figures 3: 3A: ROC curves for BD (Balloon deflation) leak volume and LVFR (Leak volume fraction ratio)
3B: ROC curves for Videolaryngoscopy grades
3C: ROC curves for Laryngeal Ultrasound parameters:
ACWBI (Airway Column Width Balloon Inflation), ACWBD (Airway Column Width Balloon Deflation) and ACWD (Airway Column Width Difference)

Table 1: Videolaryngoscopy grading scale for laryngeal lesions

0	No injury or hyperemia
1 (Mild)	Supraglottic edema
2 (Moderate)	Both supraglottic and glottic edema and/or the presence of vocal process granuloma, vocal cord ulcers and/or arytenoid luxation
3 (Severe)	More intense supraglottic and glottic edema with or without hematomas
4 (Very severe)	Involvement of subglottic lesion, vocal cords dysfunction

Table 2: Baseline characteristics of all patients

		PES				Chi-square value	P-value
		N (n=57)		P (n=23)			
Age (yrs)		46.61	15.67	48.13	20.40	-0.358	0.721
Sex	Female	17	29.8%	9	39.1%	0.647	0.421
	Male	40	70.2%	14	60.9%		
Body mass index	Obese class 1	1	1.8%	0	0.0%	4.07	0.254
	Obese class 2	0	0.0%	1	4.3%		
	Normal	39	68.4%	18	78.3%		
	Overweight	17	29.8%	4	17.4%		
Co-morbidities	CKD*	0	0.0%	3	13.0%	7.724	0.022
	Diabetes mellitus	3	5.3%	6	26.1%	7.117	0.015
	Hypothyroidism	0	0.0%	1	4.3%	2.510	0.287
	Opioid addict	0	0.0%	1	4.3%	2.510	0.287
	Chronic liver disease	0	0.0%	1	4.3%	2.510	0.287
	Hypertension	3	5.3%	5	21.7%	4.943	0.040
	CVA#	0	0.0%	1	4.3%	2.510	0.287
Factors related to intubation	Elective	26	45.6%	14	60.9%	1.526	0.217
	Emergency	31	54.4%	9	39.1%		
	Direct Laryngoscopy	57	100.0%	22	95.7%	2.51	0.113
	Video laryngoscopy	0	0.0%	1	4.3%		
	Day of intubation	5.42	2.44	7.00	7.13	-1.482	0.143
	Cuff pressure	19.74	4.40	18.22	3.52	1.475	0.144
	SOFA^ score	3.93	1.90	4.39	2.06	-0.960	0.340
	Serum albumin	3.30	0.84	3.00	1.01	1.394	0.167
	Cumulative fluid balance	660.47	770.95	712.35	656.01	-0.284	0.777
	Average RAAS# Score	-0.68	1.47	-0.43	0.84	-0.765	0.447
	Tube size	7.98	0.28	7.93	0.35	0.638	0.525

*CKD= Chronic Kidney Disease, †CVA= Cerebrovascular Accident, ‡SOFA= Sequential Organ Failure Assessment
§RAAS= Richmond Agitation and Sedation Scale

Table 3: Mean values of cuff leak test, laryngeal ultrasound and videolaryngoscopy parameters in both groups

PES	N		P		Z	P-value
	Mean	SD	Mean	SD		
CLV*	304.74	118.84	117.65	123.15	6.307	0.001
LVFR† (%)	49.25	15.29	23.13	23.38	5.891	0.001
ACWBI‡ (mm)	4.74	3.31	3.87	2.64	1.129	0.262
ACWBD§ (mm)	3.99	2.94	3.22	2.25	1.117	0.267
ACWD‖ (mm)	0.80	0.46	0.61	0.72	1.373	0.174
VL¶ Scale	0.18	0.43	1.17	0.98	-6.355	0.001

*CLV: Cuff Leak Volume, †LVFR: Leak Volume Fraction Ratio, ‡ACWBI: Airway Column Width Before Inflation, §ACWBD: Airway Column Width Before Deflation, ||ACWD: Airway Column Width Difference, ¶VL: Videolaryngoscopy,N: No Post-Extubation Stridor, P: Post-Extubation Stridor present

Table 4: Comparison of sensitivity, specificity, positive predictive value, negative predictive value and accuracy of cuff leak test, laryngeal ultrasound and videolaryngoscopy parameters and their various combinations for prediction of post-extubation stridor.

	Cut off value	Sensitivity (95% CI)	Specificity (95% CI)	Positive Predictive Value (95% CI)	Negative Predictive Value (95% CI)	Accuracy (95% CI)
CLV*(m)l	< 245	91.30% (72-98)	77.19% (85.1-98.8)	61.76% (64.6-87.3)	95.65% (49.6-72.6)	81.25% (71-89.1)
LVFR† (%)	< 28	65.22% (42.7-83.6)	94.74% (85.4-98.9)	83.33% (61.5-94)	87.10% (79.4-92.2)	86.25% (76.3-92.9)
CLV+LVFR		73.91% (51.6-89.8)	94.74% (85.4-98.9)	85% (62.1-96.8)	90% (79.5-96.2)	88.75% (79.7-94.7)
ACWB‡I(mm)	< 4.8	62.50% (35.43-84.80)	60.00% (40.6-77.34)	45.45% (31.82-59.81)	75.00% (59.91-85.76)	60.87% (45.37-74.91)
ACWBD§ (mm)	< 3.25	60.87% (38.54-80.29)	63.16% (49.34-75.55)	40.00% (29.37-51.67)	80.00% (69.83-87.36)	62.50% (50.96-73.08)
ACWD‖ (mm)	< 0.45	56.52% (34.5-76.8)	78.95% (66.1-88.6)	52.00% (36.9-66.7)	81.82% (73.5-88)	72.50% (61.4-81.9)
VL¶ Scale	> 2	52.17% (30.6-73.2)	92.98% (83-98)	75.00% (51.9-89.3)	82.81% (75.8-88.1)	81.25% (71-89.1)
CLV+LVFR		73.91% (51.59-89.77)	94.74% (85.38-98.90)	85.00% (62.11-96.79)	90.00% (79.49-96.24)	
VL+ACWD		30.43% (13.21-52.92)	80.70% (68.09-89.95)	38.9% (17.30-64.25)	74.2% (61.5-84.47)	
LV+LVFR+VL		26.09% (10.23-48.41)	96.49% (87.89-99.57)	75.00% (34.91-96.81)	76.4% (64.91-85.60)	
LV+LVFR+AC WD		47.83% (26.82-69.41)	94.74% (85.38-98.90)	71.43% (49.20-95.34)	75.34% (70.39-90.24)	
VL+LV+LVFR +ACWD		21.71% (7.46-43.70)	96.49% (87.89-99.57)	78.60% (29.04-96.33)	81.82% (63.86-84.68)	

*CLV: Cuff Leak Volume, †LVFR: Leak Volume Fraction Ratio, ‡ACWBI: Airway Column Width Before Inflation, §ACWBD: Airway Column Width Before Deflation, ||ACWD: Airway Column Width Difference, ¶VL: Videolaryngoscopy

Discussion

PELE and PES are common complications of intubation that may lead to post-extubation respiratory failure, requiring reintubation. This study was conducted to compare the performance of CLT, LUS and VL in prediction of successful extubation in mechanically ventilated patients. We found that CLT had greatest sensitivity and NPV. LVFR and VL grades showed a high specificity and PPV. Accuracy was highest for LVFR and lowest for ACWD.

The incidence of PES in our study was 28.8% and all patients who developed PES required reintubation. Previous studies have reported a 4-37% prevalence of post-extubation airway obstruction. [1,5] The presence of a higher incidence of laryngeal edema may be because majority of our patient population consisted of trauma patients. The fact that ours is a tertiary care educational institute, many times patients in emergency are intubated by trainees, who may require more than one attempt for intubation. This may also have contributed to higher incidence of PES in our patient population. Since all of our patients developed a stridor with severe respiratory distress, they had to be reintubated.

We also found that PES incidence is higher in patients with co-morbidities like DM, hypertension, and CKD. It has been studied that patients with DM may have stiff joint syndrome leading to difficult intubation, [22] hence higher chances of PES. Higher incidence in hypertension and CKD may be because of co-existence of all these diseases.

We found a higher sensitivity of CLT for detection of PES. As CLT is a screening test, a highly sensitive test would not miss subjects likely to have PES. A considerable number of studies on CLT have been published. [1–6,20–26] Most of these documented a higher specificity and negative NPV, thus inferring that patients with values above a certain threshold were less likely to develop PES and also suggesting that CLT is beneficial in ruling in than ruling out a disease. [1,6] Although the cut-off points for CLT remain controversial, previous studies mostly had lower cut-off values (110ml), [5,6] in contrast to a higher cut-off of 245 mL in our study. Given considerable differences in the cut-off points for CLV between the previous studies, delaying extubation or starting PES treatment merely based on this might be challenging. CLT calculates total leak volume (sum of inspiratory and expiratory leak), hence inspiratory TV also influences the amount of leak. Other patient factors and ventilator parameters like compliance, inspiratory flow, expiratory airflow, expiratory time, and air trapping can also influence its values. [14] Hence patient population differences could have contributed to variability in values of CLT parameters.

We noticed that patients with LVFR of > 28% had a high specificity, NPV, and accuracy for PES. This would possibly be due to the reason that other confounding factors (height, weight, gender, etc.) are adjusted for by this method. [8] This finding corroborates with a few previous studies that have found a higher specificity and NPV for this test. We found that specificity, NPV, and accuracy significantly increase when we combine CLT with LVFR. The cut-off of > 28% for LVFR is higher is compared to the usual cut off of 10% as mentioned in previous studies. [5,6] This can be due to various confounding factors such as lung compliance, inspiratory flow, airway resistance, expiratory time and air trapping which we have not taken into account.

LUS has been used as another method to predict post-extubation complications. We found that patients with an ACWD cut-off value of <0.45 had a significantly higher incidence of PES. These results are comparable to the previous studies, [9,10,23–25] although the cut-off values in our study are slightly lower. A recent meta-analysis documented that range of ACWD cut-off values for PES prediction varies from 0.45 to 1.6mm. [14]

Despite significant differences in the LUS values between PES and non-PES groups in our study, we found that of all the tests that we included, ACWD had the lowest sensitivity, PPV, and accuracy. This is in concordance with other previous studies, [10,26,27] which similarly had found a low PPV, sensitivity, and specificity for predicting PES or post-extubation laryngeal injuries. Although we found the test to be less sensitive, specificity of ACWD in our study was comparable to the pooled specificity calculated in the meta-analysis. [14] ACWD had a very low accuracy. The quality of upper airway ultrasound demands technical proficiency and competent interpretation of the sonogram and hence is operator dependent. Although studies have shown a shallow learning curve for airway ultrasound, these studies were predominantly conducted for the confirmation of ET placement after intubation. [11,28] We found that image acquisition for ACWD calculation at the time of extubation is technically challenging, as patients cannot be heavily sedated near extubation and they are coughing when neck is extended and cuff deflated.

We found significantly higher VL grades in PES group when compared to non-PES group and very high specificity, NPV, and accuracy of the test. The data for VL is sparse and is limited only to case series. [7,18]

VL is promising as it enables the visualization of peri-glottic structures and abnormalities, vocal cord mobility, and allows identification of types and extent of lesions. It also helps us to distinguish structural abnormalities of larynx (laryngeal edema) from functional abnormalities (laryngospasm) and may potentially identify the cause of laryngeal narrowing, thus guiding treatment. However, videolaryngoscopic examination is invasive, requires specific equipment and expertise and patient sedation, which may slightly delay the time to extubation.

Flexible fibreoptic laryngoscopic evaluation and grading of lesions of the larynx in patients with prolonged intubation has been described to be the most diagnostic method for PES prediction. [24] But videolaryngoscopy has more advantages like simpler equipment and wider visualization of structures. Also, video laryngoscopes are portable, faster, and easier to set up, clean, and store. This makes them convenient to use for assessment of extubation. [7,17,18,29]

On analysis of the combination of parameters (CLT+LVFR+ACWD+VL), we found that combinations yielded maximum specificity with lower accuracy and very low sensitivity. Even though all these parameters have been extensively studied, there is still no consensus on the topic. Hence, we propose an algorithm that may help us to approach a patient for prediction of PES before extubation.

We suggest performing a cuff leak test in all ventilated adults who meet the extubation criteria. Because of its high sensitivity and NPV, it would have fewer false negatives and hence would screen the patients who may develop PES. But because the cut-off values of CLT are very variable, in patients with positive CLT, we should proceed with calculating LVFR and then videolaryngoscopy for assessment VL grade. We have found that these tests are more specific and hence have fewer false positives. Patients showing positive results with these tests may have high chances of developing PES and they should be optimized before extubation. ACWD, although showed some significance for PES prediction, has practical problems and also had least accuracy in our study.

Limitations

The size of ET may affect the leak volume and ACWD, thus limiting prediction capacity of both tests. In our study, standard size ET was used in all patients (7.5 for females and 8 for males). Secondly, as cough occurring during balloon deflation can also affect the values, patients were lightly sedated, and all measurements were taken when patients were not coughing.

Conclusion

Our study demonstrated that for PES detection, CLT has a very high sensitivity, NPV, and accuracy and would be useful for screening patients likely to develop PES. Specificity and accuracy of this test is improved by combining it with LVFR. Patients with higher VL grades had a high specificity, NPV, and accuracy for PES. ACWD in our study had least sensitivity, specificity, and accuracy and should be used only in combination with other parameters. We also suggest that an algorithmic approach would be beneficial for assessment of PES in patients planned for extubation.

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