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Laryngeal ultrasound versus cuff leak test in prediction of post extubation laryngeal edema

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Abstract: The Post extubation Laryngeal edema is a common cause of obstruction of the upper air way after extubation in critical care patients and is thought to arise from direct mechanical trauma to the larynx by the endotracheal tube. The severity of airway obstruction due to laryngeal edema varies up to emergency reintubation. Reintubation itself is associated with increased mechanical ventilation days and length of stay in the critical care unit, higher costs, morbidity and mortality. There is a substantial need to identify a test to confirm or exclude the presence of significant laryngeal edema before extubation. The purpose of this study was to determine the accuracy of bedside ultrasound in the ICU in predicting post extubation stridor (PES) versus the cuff leak test. The current study was a prospective observational cohort study enrolled 75 patients admitted to AIN SHAMS Main University Hospital, who were planned for extubation. The air column width difference (ACWD) was measured before planned extubation using portable ultrasound and cuff leak test was measured by the spirometery function of the mechanical ventilation The primary goal was to assess the diagnostic accuracy of ACWD to predict the presence of significant laryngeal edema, enough to cause PES. The results showed that the prevalence of LE was 18.7%. The data collected from patients, with and without, PES showed no definite risk factors for PES. A cut off point of 0.9 mm change in ACWD (air column width difference at vocal cords) was identified (p= 0.0014), below which high probability of developing PES was noticed. The sensitivity and specificity of ACWD below or equal to 0.9 mm were 88% and 82% in predicting PES respectively, with negative predictive value of 0.83 and positive predictive value of 0.86. while the cuff leak test on cutoff point of 110 ml show p value equal 0.0016 with senetivity and specifity of68% and 89% with negative predictive value of 0.87 and positive predictive value of 0.69.
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1. Introduction

Endotracheal intubation is indicated in several clinical situations in ICU patients including acute respiratory failure, impending respiratory failure, air way protection in upper airway obstruction or patients at risk for aspiration, most commonly due to altered mental status. In addition, elective intubation is performed for many operative procedures **(Griesdale et al., 2008).**

However, intubation/extubation may lead to the development of complications such as post-extubation stridor laryngeal edema, one of the most frequent causes of reintubation, prolonged mechanical ventilation and increased morbidity in the ICU patients, especially those who are intubated for more than 24 h **(Hashemzadeh et al., 2012), (Jaber et al., 2003).**

Factors associated with the development of post-extubation stridor laryngeal edema include older age, female gender, size of endotracheal tube, presence of cuffed tube, prolonged intubation period, presence of an underlying airway disease, traumatic intubation, tracheal aspiration, tube mobility and patient fighting against the endotracheal tube **(Jaber et al., 2003), (Miller and Cole, 1996).**

Cuff leak test illustrating a leak around the endotracheal tube with the cuff deflated, has been proposed as a simple method of predicting the occurrence of post extubation laryngeal edema. Cuff leak test is measured when the patient presumed ready for extubation, it consists of deflating the balloon cuff of the endotracheal tube in order to assess the air leak around the tube, permitting an indirect evaluation of upper airway patency. A reduced cuff-leak volume identifies a population at increased risk for the development of post extubation laryngeal edema **(Engoren, 1999), (Miller and Cole, 1996).**

However, **Engoren** (1999) reported a high negative predictive value, but a low positive predictive

value, for the cuff-leak test. Although the cuff-leak test is safe and simple, the controversial results may cause physicians to make difficult decisions regarding extubation if the cuff-leak test is positive.

Ultrasound has emerged as a potentially useful bed side non invasive tool in assisting and visualization of the upper air way In addition, laryngeal ultrasonography including measurement of air column width during balloon inflation and deflation and detecting air column width difference could predict post extubation laryngeal edema **(Hertz et al., 1970), (Shih et al., 1997).**

Aim of the Work

The aim of this prospective study is to evaluate diagnostic accuracy of ultrasound in measuring air way column difference (ACWD) versus cuff leak test in predicting post extubation laryngeal edema.

2. Patients and Methodology

Our study was conducted on seventy five consecutive patients admitted to the Critical care department at Ain Shams University Hospital intubated for at least 36 h. from the period from May 2018 to February 2019.

Inclusion criteria:

1. Both sexes.
2. Intubated and mechanically ventilated for a minimum of 36 h.
3. Patients who are ready for extubation.

Exclusion criteria:

1. Age <18 years.
2. Patients primarily intubated for the upper airway obstruction.
3. Patients with laryngeal carcinoma.
4. Previous tracheostomy.
5. Neck radiotherapy.
6. Patients with vocal cord paralysis with clinical presentation of stridor.

Data were collected from the patients as follows

A: Demographic data

- ✓ Age.
- ✓ Gender.
- ✓ Smoking.
- ✓ Co-morbidities (DM, HTN, cardiac, renal or COPD)

B: Data of mechanical ventilation

- ✓ Tube size.
- ✓ Cuff pressure.
- ✓ Total intubation period were detected .

C: Post extubation stridor was confirmed by: .

- ✓ High-pitched sound produced requiring medical intervention.
- ✓ Associated with respiratory distress within 24 hours of extubatin.
- ✓ Accompanied with a respiratory rate more than 30/minute or increase by more than 10/minute from the base line.

D: Cuff pressure:

Endotracheal tubes used were cuffed tubes, presence of cuff prevent aspiration, air leak and tube dislodgement. Endotracheal tube cuff was inflated with air (around 10-15 cc air for tubes size of 7-8) and a manometer was used to detect cuff pressure in mmHg where the cuff pressure was kept between 18 to 25 mmHg.

Cuff leak test:

Cuff leak test is non-invasive and relatively easy to perform and is thought to give an indication of the patency of the upper airway. When the ventilated patient is allowed to exhale with a deflated cuff, expired air normally escapes from the otherwise closed circuit. Where the volume of leaked air can be measured by spirometry functions of the ventilator. In a case of significant laryngeal edema, the lumen of the larynx is narrowed and this results in a smaller measured air leak and the cuff leak test will then be classified as positive. CLT was measured when the patient presumed ready for extubation, permitting an indirect evaluation of upper airway patency. A reduced cuff-leak volume identifies a population at increased risk for the development of PES.

Measurement of the cuff leak volume

- ❖ Before performing the cuff leak test, first good suction of endotracheal and oral secretions was done
- ❖ Set the ventilator in the assist control mode.
- ❖ Short acting sedation (propofol 20-40mg till sedation occurred or midazolam) was used to control mode of ventilation and tidal volume.
- ❖ With the cuff inflated, record displayed inspiratory (pre-setted volume) and expiratory tidal volumes (measured volume) to see whether these are similar.
- ❖ Deflate the cuff.
- ❖ Directly record the expiratory tidal volume over the next six breathing cycles as the expiratory tidal volume will reach a plateau value after a few cycles.
- ❖ Average the three lowest values within 1 minute.
- ❖ The difference between the inspiratory tidal volume (measured before the cuff was deflated and the averaged expiratory tidal volume after cuff deflation is the cuff leak volume.

Laryngeal ultrasound

The laryngeal US was performed with a PHILIPS U/S, probe liner (7/5 MHz) for the visualization of the vocal cords.

The air column width was measured in the following steps:

- Patients were put in supine position while the neck was hyperextended.
- The test was performed with the same settings as the CLT with the patient sedated using short acting sedation (propofol 20-40 mg or midazolam), with balloon cuff inflated and deflated.
- The laryngeal air column width was defined as the width of air passed through the vocal cords as determined by US.
- The vocal cords (VC) were visualised, sonographically, in the transverse plane, through the anterior neck at the level of the cricothyroid membrane and the air-column was clearly demonstrated.
- With the cuff balloon were inflated The air-column was square-shaped and the air-column width could easily be measured.
- The arytenoids cartilage was clearly shown when the cuff balloon was inflated.
- After cuff deflation the air-column became trapezoidal in shape and masked the arytenoid cartilage when the balloon cuff was deflated.
- The width of the top of the trapezoidal air-column was measured. Hence, the air-column width difference could easily be measured.
- The false VC was also visualised, using US, as paired, hyperechoic structures, due to the presence of fibrofatty tissues.
- The true VC appeared as hypoechoic structures because they consisted of muscles.
- The air-column width difference (ACWD) was the difference in width of air column during balloon cuff inflation and deflation.
- It was recorded for three consecutive times and the averaged value was recorded.

Statistical analysis of the data (Kotz et al., 2006)

Data were fed to the computer using IBM SPSS software package version 20.0 (**Kirkpatrick et al., 2013)**

3. Results

This study was a prospective randomized clinical trial and conducted on seventy five consecutive patients admitted to the Critical care department at Ain Shams University Hospital intubated for at least 36 h., in the period from May 2018 to February 2019.

Table (1) shows demographic data of the studied patients group. Age < 50 was 32(42.7%) and >50 was 43(57.3%). Age ranged from 20-77 with mean value 52.28±12.78. Males were 41 (54.7%) and females were 34 (45.3%). Table show also co-morbidities of the studied patients with more than one disease in the same patient where HTN cases were higher with 34(45.3%) followed by DM cases with 25(33.3%) and AF with 18(24%). Smoking cases were 37(49.3%) and non-smoking cases were 38(50.7%). As regard causes of intubation the table show DCL was the most common cause of intubation in our study cases due to hemorrhagic and ischemic stroke 31(41.3%) followed by shock cases with 21(28%) and R.F type 2 with 12(16%).

Table (2) shows distribution of the studied patients group regarding the tube size used. Tube size 7.0 was 25(33.3%), tube size 7.5 was 33(44%) and tube size 8.0 was 17(22.7%). Also the table shows distribution of the studied patients group regarding cuff pressure. Cuff pressure ≤ 20 was 39 (65.0%) and > 20 was 21(35.0%). Cuff pressure ranged from 18-25 mmHg with mean value 20.7±2.04. As regard duration of intubation the table show that duration of intubation < 5 days was 40(53.3%) and ≥5 days was 35(46.7%). It ranged from 2-10 with mean value 4.64±2.19.

Table (3) shows distribution of the studied patients group regarding the incidence of PLE. PES was 14 (18.7%) and no PES was 61(81.3%).

Table (1): Demographic data of the studied patients group, as regard age, sex, comorbidities and causes of intubation.

variable	*number*	*percent*
Age		
< 50	32	42.7
>50	43	57.3
Range	20.0–77.0	
Mean	52.28	
S.D.	12.78	
SEX		
Male	41	54.7
female	34	45.3
Co-morbidities		
No past history	13	17.3
DM	25	33.3
HTN	34	45.3
AF	18	24
COPD	6	8
ESRD	5	6.7
HF	7	9.3
SMOKING	37	49.3
Cause of intubation		
DCL (CNS stroke)	31	41.3
Shock	21	28
R.F type I	5	6.6
R.F type II	12	16
R.D and bulbar manifestation	6	8

Table (2): Distribution of the studied patients group regarding the tube size used, cuff pressure and duration of intubation.

Variable	Number	Percent
Tube size		
7.0	25	33.3
7.5	33	44.0
8.0	17	22.7
Cuff pressure		
≤ 20	39	65.0
> 20	21	35.0
Range	18.0-25.0	
Mean	20.7	
S.D.	2.04	
Duration of intubation (days)		
< 5 days	40	53.3
≥ 5days	35	46.7
Range	2-10	
Mean	4.64	
S.D.	2.19	

Table (3): Distribution of the studied patients group regarding the incidence of PES.

Results	**Number**	**Percent**
PES	14	18.7
No PES	61	81.3

Table (4) shows distribution of the studied patients group regarding to the incidence of re-intubation rate during the first 24h after extubation where 30 case where re intubated due to different causes while 8 cases out this 30 case where re intubated due to stridor. This make the percentage of cases re intubated due to stridor 10.6% of all cases while this percentage is 57.5 regarding to the PES group.

Table (4): Distribution of the studied patients group regarding to incidence of re-intubation of cases in the first 24 hour.

Variable	**Number**	**Percent**
Re-intubation rate in all cases		
Yes	30	40.00
No	45	60.00
Re-intubation rate in PES group Total number (14)		
Yes	8	57.2
No	6	42.8

Table (5) shows comparison between PES and Non PES patients regarding Laryngeal ultrasound (ACWD). In PES cases, ACWD ranged from 0.3-1.5 with mean value 0.779±0.338 and in No PES ranged from 0.5-2.2 with mean value 1.43±0.43.

There was statistical significant relation between PES and Non PES patients regarding Laryngeal ultrasound (ACWD) ($P < 0.05$).

Table (7) show that there is no significant statistical relationship in this study where found between PES incidence and age (P value (0.661)), sex (P value (0.539)), cuff pressure (P value (0.611)), tube size (P value (0.083)) and duration of intubation (P value (0.105)).

Table (5): Comparison between PES and Non PES patients regarding Laryngeal ultrasound (ACWD).

	PES	No PES	t-test	P
ACWD (mm)				
Range	0.3-1.5	0.5-2.2		
Mean	0.779	1.43		
S.D.	0.338	0.43	4.02	0.0014*

t-test = Student t-test p is significant if < 0.05 Significant difference*

Table (6) shows comparison between PES and Non PES patients regarding the cuff leak test In PES, Cuff leak test ranged from 86-275 with mean value 145.11±76.32 and in No PES ranged from 98-410 with mean value 294.93±100.46.

There was statistical significant relation between PES and Non PES patients regarding cuff leak test (P < 0.05).

Table (6): Comparison between PES and Non PES patients regarding cuff leak test.

	PES	No PES	t-test	P
Cuff leak test (ml)				
Range	86-275	98-410		
Mean	145.11	294.93	4.65	0.0016*
S.D.	76.32	100.46		

t-test = Student t-test p is significant if < 0.05 Significant difference*

Table (7): Show relation between incidence of PES and age, sex, cuff pressure, tube size and duration of intubation.

Variable	No PES	PES	t-test or X^2	P value
Age				
Range	21.00-77.00	20.00-72.00	t-test=0.411	0.661 N.S.
Mean	51.96	53.64		
S.D.	11.83	16.72		
Sex				
Male	33(54.1%)	8(57.1%)	X^2=0.043	0.539 N.S.
Female	28(45.9%)	6(42.9%)		
Total	61(100%)	14(100%)		
Cuff pressure				
Range	18-22	18-25	t-test=0.26	0.611N.S.
Mean	19.33	20.16		
S.D.	1.63	1.79		
Tube size				
7.00	23(37.7%)	2(14.3%)	X^2=4.974	0.083N.S.
7.50	27(44.3%)	6(42.9%)		
8.00	11(18%)	6(42.9%)		
Total	61(100%)	14(100%)		
Duration of intubation				
Range	2.00-10.00	2.00-8.00	t-test=0.952	0.105 N.S.
Mean	4.44	5.50		
S.D.	2.16	2.24		

t-test = Student t-test X^2 = Chi square test p is significant if < 0.05N.S. = Not Significant difference

Table (8): The accuracy of ACWD in predict the stridor result.

Test Result Variable	Area Under the curve	Cut off value	sensitivity	specificity	PPV	NPV
ACWD	***0.875***	***0.932***	***88.0***	82.0	***86.0***	***83.0***

PPV = positive predictive value NPV = Negative predictive value

Table (9): The accuracy of Cuff leak test in predict the stridor result.

Test Result Variable	Area Under the curve	Cut off value	sensitivity	specificity	PPV	NPV
Cuff leak test	***0.73***	***110***	***68.0***	89.0	***69.0***	***87.0***

PPV = positive predictive value NPV = Negative predictive value

Table (10) comparison between the accuracy of ACWD and cuff leak test where ACWD show Sensitivity and Specificity of (88.0% and 82%) respectively and PPV and NPV of (86% and 83%) respectively with cut of point of 0.932 mm with area under the curve 0.875 while the cuff leak test show Sensitivity and Specificity of (68.0% and 89%) respectively and PPV and NPV of (69% and 87%) respectively with cut of point of 110 ml with area under the curve 0.73. where the greater the area under the curve the better the test.

Table (10): Show comparison between accuracy of ACWD and cuff leak test

Variable	ACWD	Cuff leak test
Area Under the curve	0.875	0.73
Cut off value	0.932 mm	110 ml
Sensitivity	88.0	68.0
Specificity	82.0	89.0
PPV	86.0	69.0
NPV	83.0	87.0

4. Discussion

Post extubation Laryngeal edema is a common cause of airway obstruction after extubation in critical care patients and is thought to arise from direct mechanical trauma to the larynx by the endotracheal tube. The severity of airway obstruction due to laryngeal edema varies up to emergency reintubation. Reintubation itself is associated with increased mechanical ventilation days and length of stay in the critical care unit, higher costs, morbidity and mortality.

Diagnosis of PES is of significant clinical importance as these patients can benefit from close monitoring and specific therapies. Nonetheless, there is no consensus on a method to identify patients at risk of PES. Cuff leak test (CLT), illustrating a leak around the endotracheal tube with the cuff deflated, has been proposed as a simple method of predicting the occurrence of PES. However, cut-off point of the cuff-leak volume substantially differs between previous studies and the controversial results may cause physicians to make difficult decisions regarding extubation if the CLT is positive, so there is a substantial need for defining risk of PES development through other methods.

The current study was a prospective cohort study included 75 mechanically ventilated patients, in Ain shams main university hospital; critical care department. In this study ultrasonography was used to predict PES according to change in air column (at vocal cords level) width and shape versus the cuff leak test to predict the presence of laryngeal edema using stridor as an accepted clinical marker for laryngeal edema.

The 75 patients were 41 male and 34 female, all cases over 18 years old with a mean age (in years) 52.28± 12.78 with 32 cases (42.7%) below 50 years old.

The main objective of this study was to identify the role of bedside laryngeal US in predicting PES which is a subject of interest in critical care medicine.

In the current study some suspected risk factors of PES were investigated such as different age groups, female gender, the duration of intubation and re-intubation times.

In different age groups there was no statistical significance as regards the incidence of PES (P 0.661)

and median age (years) in the negative group was 51.96 while in the positive group was 53.64 with no statistical significance as regards the incidence of PES in both groups.

This results were similar to the results reported in both L-W Ding et al. with age (y), mean ± SD (72.24 ± 17.71) in the PES group and (66.86 ± 12.74) in the no PES group and which had no statistical significance (P 0.142) and Yuda Sutherasan et al. with age (y), mean ± SD (71± 20) in the PES group and (67± 10.5) in the no PES group and demonstrating no statistical significance (P 0.57). where this result were against the results reported in Keeratichananont et al with age (y), mean ± SD (70 ± 21.8) in the PES group and (55.4 ± 18.2) in the no PES group and which had statistical significance (P 0.003).

This study showed no statistical significance as regards the incidence of PES in different gender groups p value (0.539). This was similar to results of multiple studies as **Francois B et al., Kriner EJ et al**. and **Chung YH et al**. On the other hand other studies showed different finding and defined Female gender as a risk factor for both laryngeal edema and PES as **Ho LI et al., Darmon JY et al., Cheng KC et al** and **Maury E et al**.

Duration of intubation in the present study was not a predictor of PES, given that the present study p value (0.105). This finding was similar to that in **Yuda Sutherasan et al., Colice GL et al**. This was contradicted in the results reported by **Esteller More E et al.** and **Tadie JM et al.**

Using US, the air column width (ACW), which is defined as the width of the acoustic shadow at the level of the vocal cords, could be measured. If the ACW is measured before and after endotracheal cuff deflation, the air column width difference (ACWD) could be calculated, so the main finding to assess that function was ACWD with observing the shape of air column width before and after tube cuff deflation. The VC were demonstrated, in the transverse plane, through the anterior neck at the cricothyroid membrane and the air-column was clearly obvious. The air-column was square-shaped and the ACW could easily be measured. The arytenoid cartilage was clearly shown with cuff balloon inflated. The air-column became trapezoidal in shape and masked the arytenoid cartilage when the balloon cuff was deflated.

The width of the top of the trapezoidal air-column was measured. Hence, the ACWD could easily calculated. The number of patients examined in this study were 75 intubated patients, 18.7% of the cases had PES representing 14 cases. The other 81.3% of the cases had no signs of PES. The results were calculated after statistical analysis of the documented data deducing a proposed cut off point (0.9 mm) below which the probability of PES is significantly higher. The cutoff point of 0.9 mm had a sensitivity of 88.0%, specificity of 82.0, PPV of 86% and NPV of 83% with p value (0.0014).

Results from the study by **L-W. Ding et al**. showed a significantly lower ACWD (0.35 versus 1.5 mm; $P < 0.01$) in patients who developed a stridor compared with patients who did not, but didn't identify a cut off point for predicting PES. Owing to the small sample size ($n = 51$), including only four patients with PES, results from this study should be interpreted with caution. In the study by **Yuda Sutherasan et al.,** similar results were found with decreased ACWD (1.08 versus 1.99 mm; $P < 0.001$) in patients who developed PES and they have identified a proposed cutoff point value at 1.6 mm of ACWD and demonstrated the high predictability of the ACWD measured by bedside ICU US with a sensitivity of 70.6%, specificity of 70.2%, high NPV of 92.2%. Both of these studied reported similar changes in the air column shape after ETT cuff deflation. Also **(Ahmed et al., 2018)** show similar result with cutoff point 0.9 mm for the ACWD sensitivity and specificity of (85.95%, 71. 95 %) respectively.

Unfortunately, these results could not be replicated in the study by **Mikaeili et al.** they reported no significant difference ACWD (0.1 versus 1.0 mm; $P = 0.59$) between patients with and without PES. This might be explained by the small sample size ($n = 41$) and the subsequent small number of patients developing PES ($n = 4$), in that study they reported a very low sensitivity and specificity of 50% and 57% respectively and PPV of 11% and NPV of 91% at a proposed ACWD of 0.85 mm concluding that cuff leak test is still a better predictor of PES than portable bedside ICU US.

CLT is used as an indirect evaluation of upper airway patency, consisting of deflating the balloon cuff of the endotracheal tube in order to assess the air leak around the tube. A reduced cuff-leak volume identifies population at increased risk for the development of PES. However, cut-off point of the cuff-leak volume substantially differs between previous studies and the controversial results may cause physicians to make difficult decisions regarding extubation if the CLT is positive.

In this study we measure the cuff leak around the ETT after deflation of the tube cuff by the spirometery function of the mechanical ventilation where the test was done on 75 mechanically ventilated patient within 24h before extubation where 18.7% of the cases had PES representing 14 cases. The other 81.3% of the cases representing 61 case had no signs of PES. The results were calculated after statistical analysis of the documented data deducing a proposed cut off point (110 ml) below which the probability of PES is significantly higher.

According to this data The cutoff point of 110 ml had a sensitivity of 68%, specificity of 89.0, PPV of 69% and NPV of 87%.p value was (0.0016).

Cuff leak test in our results represented a predictor for PES. Patients with PES had CLT < 110 ml with sensitivity and PPV of 68% and 69% respectively (P value 0.0016) and this was in concordance with **Miller and Cole** who showed that a cuff leak volume of <110 ml might be indicative of patients at risk for PES where they found that leak in PES versus non PES was (180 +/- 157 mL vs 360 +/- 157 mL; p = 0.012) with specificity of 99% and sensitivity 67%. and **(Wang et al., 2007)** where they found that Cut-off leak threshold values of less than 88 ml and less than 18% were identified to predict the occurrence of stridor with sensitivities of 60% and 55%, respectively and specificities of 88.9% and 88.9%, respectively. The positive and negative predictive values for a cut-off leak threshold of less than 88 ml were 54.5% and 90.9% p value was (p = 0.012). also **Keeratichananont et al** showing that cuff leak volume of less than 114 ml was used to predict post-extubation stridor with the sensitivity of 89%, specificity of 90%, positive predictive value of 65% and negative predictive value of 98%, respectively. but Schnell et al show poor prognostic value of the cuff leak test where they found that cuff leak tests display poor diagnostic accuracy: sensitivities ranging from 27% to 46%, specificities from 70% to 88%, positive predictive values from 14% to 19% and negative predictive values from 92% to 93%. Also **(Ahmed et al., 2018)** show similar result in the cuff leak test with cutoff point of 120 ml with sensitivity and specificity of (72.95%, 86.95%) but with cutoff point of 220 show sensitivity and specificity of (90 %, 65 %)

That was in contrary to **Mikaelie et al** who showed less sensitivity (25%) with CLT less than 110mm and 130mm and high sensitivity (75%) with CLT 249mm and also with Ding, Wang, et al who mentioned significant statistical value for CLT (P-Value 0.01) but with CLT of 300mm. Also **Engoren** showed great controversy in CLT accuracy and low positive predictive value (0%) in the cardiac surgery population. Engoren reported that all three PES cases had CLT values of >310 mL.

The difference between cut-off values in the different studies may probably be due to different endotracheal tube size leading to different resistance in the endotracheal tube with more resistance and larger cuff leak volume with smaller tube size. Also airway secretions encrusted on either the tube lumen or the outer part of the tube beneath the VC may increase resistance. We tried to reduce this phenomenon by gentle oral and tube suction before the measurement.

There is still debate on cut off points for CLT in predicting PES. Most studies on cuff leak volume documented high specificity and negative predictive values, implying that patients with a cuff leak volume above a certain threshold had low probability of developing PES. Nevertheless, low sensitivity and PPV of these methods might be indicative of their limited values in predicting PES. Considering their cut off points (<110 ml and <130 ml), Altogether, clinical decision-making to start PES treatment merely based on CLT results might be challenging.

In the present study re-intubation was the final decision in 30 of the extubated cases 8 of them had PES and where stridor was the main cause of re-intubation forming 26% of all re-intubated cases confirming the threat posed by PES in the ICU and the need to continue searching for a predictive test to confirm or exclude the presence of significant laryngeal edema before extubation.

Conclusion

Bed side ICU ultrasound measuring ACWD between predeflation and post-deflation of ETT cuff balloon with cutoff point of 0.9 is a tool of a good prospective in predicting PES.

Recommendations and Limitation

1. Portable bedside US should considered before extubation as a tool to predict or to exclude the presence of significant laryngeal edema.
2. Planned training programs on bedside ultrasonography for ICU staff should be initiated to increase the familiarity with ultrasonography application for predicting PES and other airway management applications.
3. There is an urgent need for further studies to be carried out on a larger number of patients to validate the results of the current study and should concentrate on methods to predict PES as it is unlikely that there will be a single sensitive and specific test for predicting PES in the near future.

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