Laryngeal ultrasound as a bedside tool in detecting postextubation stridor in patients with respiratory illness

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Received 05 October 2018
Revised 16 October 2018
Accepted 23 October 2018
Published 05 February 2020

Journal of Current Medical Research and Practice
2020, 5:36–40

Context
Postextubation stridor is a serious complication in respiratory ICU. Laryngeal ultrasound (US) could be helpful in its diagnosis.

Aim
The aim was to evaluate accuracy of laryngeal US in detecting postextubation stridor in patients with respiratory illness.

Patients and methods
A prospective observational study was conducted. A total of 167 mechanically ventilated patients were consequently included over a 2-year period. Laryngeal US air column width (ACW) was measured just after intubation and at the time of extubation. Air column width ratio (ACWR) (ACW before extubation/ACW after intubation) and air column width difference (ACWD) at the time of extubation (ACW with cuff deflated-ACW with cuff inflated) were calculated.

Statistical analysis
Statistical Package for the Social Sciences statistical software computer program version 20 and Medcalc v. 11.6 were used. Nonparametric tests were used.

Results
Among the included patients, 17 (10.2%) patients developed stridor. Both ACWR and ACED were significantly lower in patients with stridor than those without stridor (0.798 ± 0.051 vs 0.893 ± 0.056, $P < 0.001$; 0.541 ± 0.326 vs 1.237 ± 0.442, $P < 0.001$, respectively). The optimum cutoff value to detect postextubation stridor was less than or equal to 0.86 for ACWR, showing area under the curve of 0.894, 82.4% sensitivity, and 84% specificity and was less than or equal to 0.65 mm for ACWD, showing 76.5% sensitivity, 90% specificity, and area under the curve 0.896.

Conclusions
US is a valuable tool in detecting postextubation stridor. US -guided ACWR and ACWD could be accurate methods for predicting postextubation stridor in RICU.

Keywords:
air column width, air column width difference, air column width ratio, laryngeal ultrasound, postextubation stridor

J Curr Med Res Pract 5:36–40

2357-0121

Introduction

Endotracheal intubation is an essential aspect of respiratory critical care. However, it may cause airway damage, leading to laryngeal edema or ulcerations. The decreased airway lumen results in an increase of air flow velocity, leading to postextubation stridor [1].

Stridor has been documented to occur in 3.5–36.8% of the ICU population [1–4]. It may progress to acute respiratory failure with reintubation rate of 46–80% [5], resulting in increased mechanical ventilation (MV) days, ICU stay, health care cost, morbidity, and mortality [6].

Cuff leak test is an early method described to predict postextubation stridor [7,8]. However, it showed a moderate accuracy to predict upper airway obstruction [9,10]. Laryngoscopy is another reliable but invasive method that enables visualization of periglottic structures and pathology [11,12]. Laryngeal US is a simple, feasible, noninvasive tool recently introduced for predicting postextubation stridor. A reduced US-guided laryngeal air column width difference (ACWD) is suggested to predict postextubation stridor [12,13]. Furthermore, decreased air column width ratio (ACWR) could be helpful in predicting postextubation stridor [14].

Aim

The aim was to evaluate the accuracy of laryngeal ultrasound (US) in detecting postextubation stridor in patients with respiratory illness.

Patients and methods

Patients

This study was conducted in the Respiratory Intensive Care Unit of Chest Diseases and Tuberculosis Department of Assiut University Hospital during the period between September 2015 and December 2017. One-hundred sixty-seven mechanically ventilated patients, who met inclusion criteria, were consequently enrolled. The study was approved by the Institutional Ethics Committee of Assiut University. An informed consent was given by all patients or their relatives.

Inclusion criteria

Patients underwent endotracheal intubation with MV owing to respiratory failure for 48 h or more.

Exclusion criteria

The following were the exclusion criteria:

(1) Patients younger than 16 years.
(2) Known cases of airway complications owing to previous intubations.
(3) Patients with enlarged thyroid gland.
(4) Malignant growth of the airways.
(5) Patients with left-sided heart failure, renal failure, liver cell failure, or neuromuscular diseases.

Work-up scheme

All patients were subjected to careful history taking. Full general and chest examinations were performed, and BMI and acute physiology and chronic health evaluation II score (APACHE II) score were recorded. All routine investigations to apply exclusion criteria were done.

During the first 48 h of MV, laryngeal US was performed for all patients.

Equipment used was MEDESION SONOACE R3 US (the portable ultrasonography device available in our ICU, made in Korea and was introduced in the market in 2010) machine equipped with a 5.0 MHz linear probe to visualize the vocal cords and measure air column width (ACW).

Patient positioning was in the form of supine sniffing position with a pillow under the occiput to achieve optimum head and neck extension.

The technique used was as follows [12] the examination was done while all patients were ventilated by assist-control mode with 5 cmH_2O of positive end-expiratory pressure. The patients' endotracheal and oral secretions were gently suctioned. The probe was placed on the cricothyroid membrane with a transverse view of the larynx. The standard scanning plane should contain several landmarks, including the vocal cords, false cords, thyroid cartilage, and arytenoids cartilage. The vocal cords, surrounding soft tissues, and the air passage through the vocal cords were observed. The laryngeal ACW was defined as the width of air passed through the vocal cords (VC) as determined by US. The air-column width was measured during endotracheal tube balloon cuff deflation and inflation over the respiratory cycles for three consecutive times, and the averaged value was recorded.

The same protocol was used for measuring ACW before extubation and for calculation of both ACWR and ACWD. ACWR is defined as ACW before extubation/ACW after intubation [14], whereas ACWD refers to ACW with cuff deflated − ACW with cuff inflated at time of extubation [12].

Postextubation stridor was diagnosed clinically. Stridor was defined as the presence of a high-pitched inspiratory wheeze localized to the trachea or the larynx and associated with respiratory distress, usually requiring medical intervention.

Results

One-hundred sixty-seven patients were included in the data analysis. Among them, 62.3% were males, and 62.9% of patients had chronic obstructive pulmonary disease as a primary diagnosis. Their mean duration of MV was 6.3 days.

Seventeen (10.2%) patients developed stridor. The mean age of patients with stridor was 59.47 years. Of them, nine patients were males and eight patients were females. Patients with stridor have significantly higher BMI (27.71 vs 23.89, $P = 0.003$) and APACHE II score (26.82 vs 23.56, $P = 0.006$) than patients who did not develop stridor after extubation. They also had significant longer duration of MV compared with those without stridor (10.59 days, $P < 0.001$) and more frequent tube change during that period. Regarding weaning outcome, they more frequently experienced difficult/prolonged weaning than those without stridor (88 vs 26%, $P < 0.001$) (Table 1).

By US assessment, they showed significant lower ACW at weaning time with much lower ACWR and

ACWD than patients without stridor (5.724, 0.798, and 0.541 mm, respectively, $P < 0.001$) (Table 2).

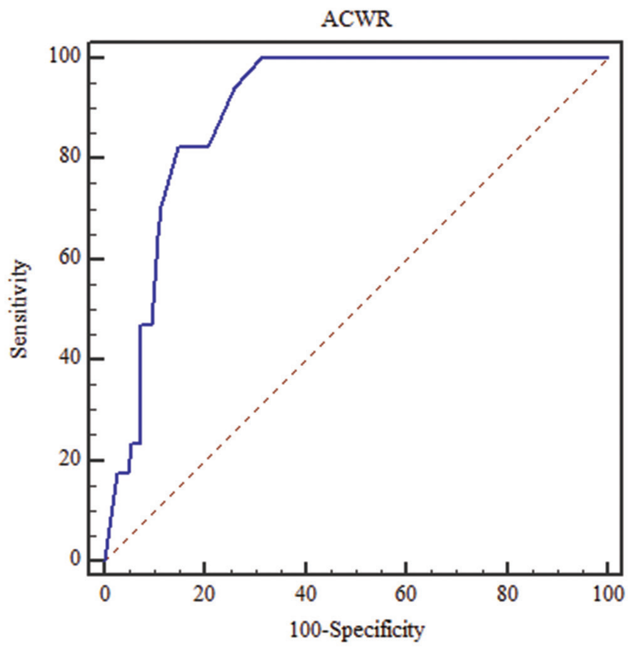
Among all factors, by binary logistic regression, BMI, APACHE II score, and mode of weaning were independent risk for stridor. Among US parameters, ACWR and ACWD were also independent risk factor for stridor (Table 3).

Receiver operating characteristic curve was applied to detect the optimum cutoff value of parameters used to predict stridor among mechanically ventilated patients. The optimum cutoff value of US-ACWR was less than or equal to 0.86, showing sensitivity of 82.4%, specificity of 84%, area under the curve (AUC) of 0.894, and diagnostic accuracy of 78% (Fig. 1). The optimum cutoff value of US-ACWD was less than or equal to 0.65 mm, showing sensitivity of 76.5%, specificity of 90%, AUC of 0.896, and diagnostic accuracy of 85% (Fig. 2). There was no significant difference between both methods ($P = 0.9367$) (Fig. 3).

The optimum cutoff value of the ACWR as screening tool for predicting stridor in MV patients was less than or equal to 0.86, showing 82.4% sensitivity and 84% specificity with AUC 0.894 and diagnostic accuracy 78%.

The optimum cutoff value of the ACWD as screening tool for predicting stridor in MV patients was less than or equal to 0.65 mm, showing 76.5% sensitivity and 90% specificity with AUC 0.896 and diagnostic accuracy 85%.

Figure 1



Receiver operating characteristic curve to evaluate the optimum cutoff value of ultrasound – air column width ratio as a screening tool for predicting stridor in mechanical ventilation patients (167 patients).

Discussion

Postextubation laryngeal edema is one of the major adverse effect of tracheal intubation which may

Table 1 Demographic, clinical, and mechanical ventilation data of patients who developed stridor vs no-stridor group

	Stridor (*n*=17) [*n* (%)]	No-stridor (*n*=150) [*n* (%)]	*P*
Age (years)			
Mean±SD	59.47±12.20	56.24±12.50	0.23
Sex			
Male	9 (52.9)	95 (63.3)	0.402
Female	8 (47.1)	55 (36.7)	
BMI			
Mean±SD	27.71±5.38	23.89±4.45	0.003**
APACHE II score			
Mean±SD	26.82±4.41	23.56±4.29	0.006**
Diagnosis			
COPD	7 (41.2)	98 (65.3)	0.017*
Non-COPD	10 (58.8)	52 (34.7)	
Duration of MV (days)			
Mean±SD	10.59±3.02	5.87±4.76	<0.001***
Previous intubation	4 (23.4)	19 (12.7)	0.218
Endotracheal tube change during MV	3 (17.6)	5 (3.3)	0.009**
Weaning type			
Simple	2 (11.8)	111 (74)	<0.001***
Difficult/prolonged	15 (88.2)	39 (26)	

APACHE II score, acute physiology and chronic health evaluation II score; COPD, chronic obstructive pulmonary diseases; MV, mechanical ventilation. *Statistically significant.

Table 2 Laryngeal ultrasound parameters of stridor vs no-stridor group

	Stridor (*n*=17) (mean±SD)	No-stridor (*n*=150) (mean±SD)	P
ACW deflation at first day (mm)	7.459±0.76	7.675±0.78	0.052
ACW deflation at weaning (mm)	5.724±0.74	6.863±0.82	<0.001***
ACW inflation at weaning (mm)	5.182±0.63	5.627±0.69	0.014*
ACW ratio	0.798±0.05	0.893±0.06	<0.001***
ACW difference	0.541±0.33	1.237±0.44	<0.001***
ACW follow up (mm)	6.364±1.13	7.686±0.81	<0.001***

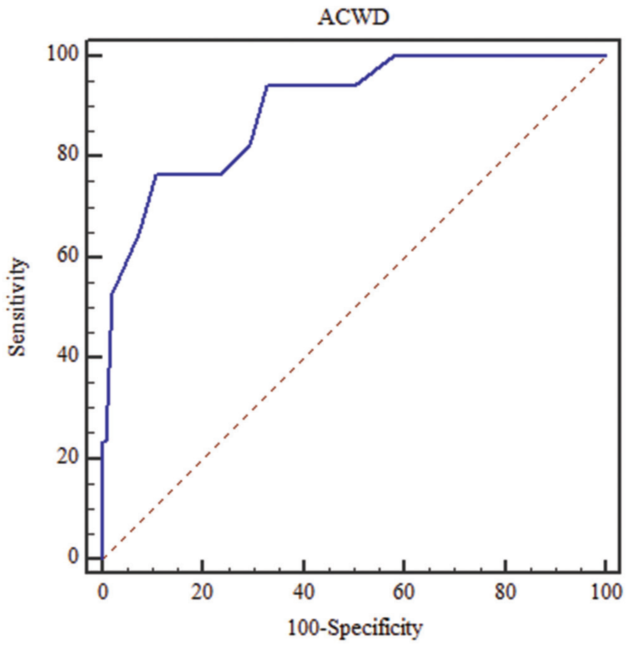
ACW, air column width; ACWD, air column width difference; ACWR, air column width ratio.*Statistically significant.

Table 3 Binary regression analysis of factors associated with stridor

	P	OR	CI 95% Lower-upper
Clinical and mechanical ventilation data			
BMI	0.0489*	1.139	0.9919-1.3085
APACHE II score	0.0487*	1.149	1.0006-1.3193
Weaning type	0.0025**	14.867	2.5795-85.6836
Ultrasonographic data			
ACWR	0.0369*	1.287	1.0405-1.3592
ACWD	0.0374*	1.215	1.0137-1.3279

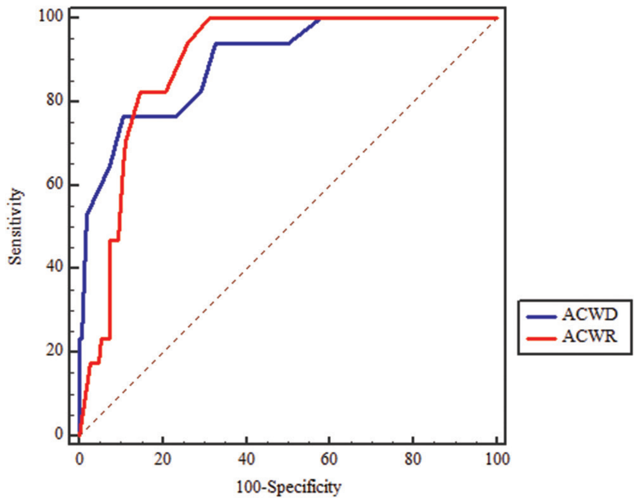
ACWD, air column width difference; ACWR, air column width ratio; APACHE II, acute physiology and chronic health evaluation II score. *Statistically significant.

Figure 2



Receiver operating characteristic curve to evaluate the optimum cutoff value of ultrasound – air column width difference as a screening tool for predicting stridor in mechanical ventilation patients (167 patients).

Figure 3



Comparison of receiver operating characteristic curves of both air column width ratio and air column width difference. Difference between areas = 0.00255 and $P = 0.9367$.

cause postextubation stridor owing to serious airway obstruction. In our study, postextubation stridor developed in 17 (10.2%) patients, with the need of reintubation in six (35%) patients. The incidence of postextubation stridor reported in literatures ranged from 3.5 to 36.8% with early reintubation rate of 46–80% [5].

Prolonged weaning, high BMI, and high APACHE II score were independent risk factors for stridor. Patients with stridor also had significantly higher frequency of tube change during MV period.

Factors associated with the development of postextubation stridor include older age, female sex, larger endotracheal tube size, prolonged intubation period, elevated APACHE II and SAPS II scores, presence of an underlying airway disease, traumatic intubation, tracheal aspiration, self-extubation, patient fighting against the endotracheal intubation, and use of myorelaxant medications [3,13,15–18].

For prediction and diagnosis of postextubation stridor, numerous modalities have been developed including cuff-leak test, laryngeotracheal US, and fiberoptic laryngobronchoscopy [1].

US imaging technique is a simple, feasible, portable, noninvasive tool that does not require any ionizing energy and is helpful for assessment and management of airway in ICU [19].

Laryngeal US evaluation of laryngeal ACW and calculation of both ACWD and ACWR were performed in our study. The air column was significantly lower in patients who developed stridor (5.72 vs 6.86 mm) as well as both ACWD and ACWR, which were found to be independent risk for stridor and had high senstivity and specificity. The optimum cutoff value to detect postextubation stridor was less than or equal to 0.65 mm for ACWD, showing AUC 0.896, 76.5% sensitivity, and 90% specificity and was less than or equal to 0.86 for ACWR, showing AUC 0.894, 82.4% sensitivity, and 84% specificity.

These results agree with Ding *et al.* [12] who, to our knowledge, were the first to report the ability of US to visualize the vocal cords and larynx and had shown some benefit for predicting laryngeal edema. They measured significantly higher mean ACW (6.4 vs 4.5 mm) and higher ACWD between predeflation and postdeflation of balloon cuff (1.5 vs 0.35 mm) in nonlaryngeal edema group. Their results also correlated with cuff leak test (CLT) and confirmed by laryngoscopy. Similarly, Sutherasan *et al.* [13] showed that ACWD is a predictor for laryngeal edema and had identified a cutoff point value of 1.6 mm of ACWD. El-Baradey *et al.* [5] also stated that ACWD (with cutoff point < 0.9 mm) not only is useful in predicting postextubation stridor but is also useful for evaluating regression of airway edema after steroid therapy.

However, US-measured ACW and ACWD showed low positive predictive value and sensitivity in predicting postextubation stridor by Mikaeili *et al.* [3] who advised the use of US with caution in this regard.

On the contrary, Venkategowda *et al*. [14] reported that ACWR of 0.8 or less may be helpful in predicting postextubation stridor.

In this study, both methods (ACWD and ACWR calculation) were comparable. However, higher sensitivity was shown by ACWR and higher specificity by ACWD. Both methods might be combined for more accurate results in case of a skilled physician's availability at times of intubation and extubation or one method to be used according to physician experience and preferability.

Limitations of the study

Personal bias could not be excluded as the US examiner was not blined to clinical data of the patients. Preventive measures such as systemic steroids and follow-up for patients at high risk of stridor by US were not examined in this study.

Conclusion

Postextubation stridor is still one of the major complications of endotracheal intubation. US-guided ACW ratio and difference could be valuable in detecting postextubation stridor in RICU.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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