Cuff Leak Volume As a Clinical Predictor for Identifying Post-Extubation Stridor

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Background: *Post-extubation stridor occurs after translaryngeal intubation results to re-intubation in a number of patients.*
Objective: *To determine the cut-off value of the cuff leak volume test among Thai patients as a predictor for post-extubation stridor.*
Material and Method: *Demographic data and cuff leak volume were collected from patients who had been intubated with planned extubation. Clinical stridor was observed and identified after extubation.*
Results: *Among 115 patients, the 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. Among the stridor group, 12 of 19 cases (63.2%) needed re-intubation.*
Conclusion: *The cuff leak volume of less than 114 ml can be used as a clinical predictor for identifying post-extubation stridor.*

Keywords: *Cuff leak volume, Laryngeal edema, Clinical predictor, Post-extubation stridor*

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Translaryngeal intubation is a life saving procedure for patients who have respiratory failure and upper airway obstruction. However, complications can arise from the endotracheal tube itself because it exerts pressure on the posterior larynx, inducing polymorphonuclear infiltration, producing fibrinous exudation, thus injuring the medial surface of the vocal cords and arytenoids cartilages, which can result in laryngeal edema and ulceration[1,2]. The incidence of laryngeal edema is between 3 to 30% and manifests clinically as post-extubation stridor, moreover 46 to 80% of these patients need early re-intubation within 48 to 72 hours secondary to upper airway obstruction, this prolongs the duration of mechanical ventilation, hospitalization, and increases morbidity and mortality[3-7].

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There are many methods for predicting the occurrence of laryngeal edema in the high risk intubated patients such as laryngoscopy, bronchoscopy and the computerized tomography scan and magnetic resonance imaging, but these techniques may have some limitations *e.g.* invasive, expensive, require at least the partial removal of endotracheal tube and some can only be used after extubation[8-10]. Cuff leak volume from the "cuff leak" test reported in 1987 by Adderley and Mullins[11] was proposed as a simple tool to detect laryngeal edema in children with croup. Subsequently, in 1996, Miller and Cole reported the reduction of cuff leak volume prior to extubation increased the risk for post-extubation stridor[12]. Thereafter, in 2005, a prospective study conducted by Kriner et al used "standardized cuff leak test", the threshold of cuff leak volume of less than 110 ml was the best cut-off value for predicting post-extubation stridor with a sensitivity of 50%, specificity of 84%, positive predictive value of 12%, and negative predictive value of 97%, respectively[13].

The present study was conducted to determine the cut-off value of the cuff leak volume test among

Thai patients as a clinical predictor for post-extubation stridor.

Material and Method

By the ethical approval and informed consent, a prospective observational study was carried out between June 1, 2008 and February 28, 2010. Inclusion criteria included all hospitalized age of 18 years old or more who had undergone translaryngeal intubation from any cause with low-pressure, high-volume cuff at least 36 hours until the weaning criteria was met assessed by their primary doctor and in those patients whom extubation was planned after receiving at least 30 minutes of T-piece oxygen. Exclusion criteria were patients with underlying upper airway obstruction, vocal cord paralysis, history of neck or larynx surgery, self-extubation, and those who needed re-intubation with other indications except upper airway obstruction.

The patients were on assist-controlled mandatory ventilation with a setting of 500 ml of tidal volume, thereafter the cuff volume leak test was performed as Kriner's study[13]. The difference between the mechanical exhaled volume (inflated with the minimal occlusive volume) and mechanical exhaled tidal volume (deflated and observed for the next six respiratory cycles, then recorded of three lowest exhaled volumes) was called "cuff leak volume".

Within 72 hours of extubation, the stridor was defined as the presence of an audible high-pitched inspiratory wheeze requiring medical intervention and usually was associated with respiratory distress. All assessments for stridor, respiratory distress, need for reintubation, and the modalities of treatment were performed by the investigator team.

The mean, and standard deviation (SD) was used to describe continuous data, and the proportion (%) was used to describe categorical data. Student t test and the Chi-square test or Fishers' exact test were used to analyze the continuous and categorical characteristics, respectively. The outcomes of interests were analyzed with SPSS version 16 software and the results were considered as statistically significant if p-value was less than 0.05.

Results

Overall, 115 subjects were finally analyzed, and the baseline characteristics are demonstrated in Table 1. Among these, there were 19/96 cases of stridor/non-stridor. The post-extubation stridor/non-stridor clinical predictors included average age ± standard deviation (SD) of 70 ± 21.8/55.4 ± 18.2 years, sex male:female of 8:11/53:43, days intubated ± SD of 11.7 ± 8.7/4.6 ± 4.9 days, mean of cuff pressure and cuff leak volume before extubation were 21.6 ± 2.7/21.8 ± 2.5 cm H_2O and 90.8 ± 55.9/256.8 ± 90.4 ml, respectively. After extubation, no one in the non-stridor group needed re-intubation due to upper airway obstruction, while 12 of 19 cases (63.2%) of stridor patients needed re-intubation due to upper airway obstruction.

There was the older age of the patients, a longer duration of intubation and a smaller cuff leak volume found in the stridor group. Cuff leak volume threshold identified by the receiver operating characteristic (ROC) curve of less than 114 ml predicted the occurrence of stridor with a sensitivity of 89%, specificity of 90%, positive predictive value of 65% and negative predictive value of 98%, respectively (Fig. 1).

Discussion

The present study showed the cuff leak volume of less than 114 ml, 4 ml difference compared with 110 ml of the study of Kriner[13]. This figure is similar but increased in all of sensitivity, specificity, positive predictive value, and negative predictive value. Therefore, the cuff leak volume determination may be

Table 1. Patient characteristics of post-extubation stridor/non-stridor group

	Stridor group (n = 19)	Non-stridor group (n = 96)	p-value
Age (years)	70 ± 21.8	55.4 ± 18.2	0.003
Sex male:female	8:11	53:43	0.296
Days intubated	11.7 ± 8.7	4.6 ± 4.9	<0.001
Cuff pressure (cmH2O)	21.6 ± 2.7	21.8 ± 2.5	0.801
Cuff leak volume (ml)	90.8 ± 55.9	256.8 ± 90.4	<0.001
Difficulty in intubation, single/multiple (%)	12:7 (63.2/36.8)	66:30 (68.8/31.3)	0.634
Re-intubation (%)	63.2	0	<0.001

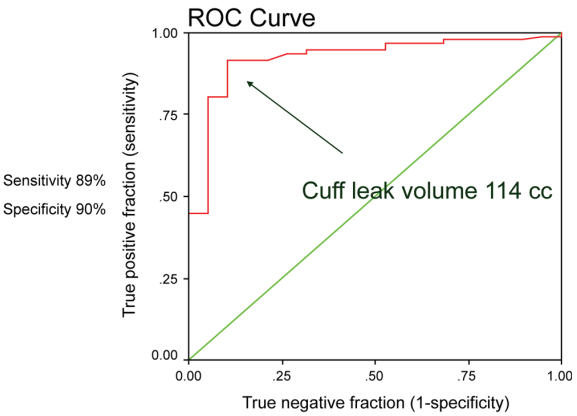

Fig. 1 Cut-off point of cuff leak volume that predict post-extubation stridor

a useful index of obstruction to airflow in the upper airway, which is presumably related to injury to the airway. However, the quantified volume of the cuff leak volume may be indirect, and partially correlate or imply toward all of the diagnostic values.

Post-extubation stridor with need re-intubation of the present study was around two-third (63.2%), markedly higher than 6 in 13 (46.1%) of Sandhu's study[14].

While a little difference in volume leak made a vast difference in diagnosis value, the several potential limitation of the present study should be considered. Firstly, the direct laryngoscopy was not conducted orderly at the time of extubation for visual or pathologic finding, correlating with the clinical outcome. Secondly, the particular mode of weaning would alter rate of post-extubation stridor due to larygotracheal injury[15,16]. Thirdly, the additional spontaneous and unmeasured patient-assisted inspiratory tidal volumes may have influenced the calculated cuff leak volume, particularly if such gas could flow through the annulus between the endotracheal tube and the airway wall when the balloon cuff was deflated[17]. Finally, the standardized approach to measuring the leak should be varied clinical experience, by the same or different observers[18].

In conclusion, cuff leak volume of less than 114 ml can be used as a clinical predictor for identifying post-extubation stridor.

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Potential conflicts of interest

None.

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ปริมาตรลมรั่วผ่านกระเปาะลมเป็นตัวทำนายคลินิกสำหรับระบุหาภาวะหายใจเสียงครางหลังถอดท่อช่วยหายใจ

วรางคณา กีรติชนานนท์, ธีรนันท์ ลิ่มทอง, สุริยา กีรติชนานนท์

ภูมิหลัง: *ภาวะหายใจเสียงครางหลังถอดท่อช่วยหายใจหลังการใส่ท่อผ่านหลอดลมเป็นเหตุให้ผู้ป่วยจำนวนหนึ่ง ต้องใส่ท่อช่วยหายใจซ้ำ*

วัตถุประสงค์: *เพื่อกำหนดค่าจุดตัดของปริมาตรลมรั่วผ่านกระเปาะลมในผู้ป่วยไทย เพื่อใช้ทำนายการเกิดภาวะหายใจเสียงครางหลังถอดท่อช่วยหายใจ*

วัสดุและวิธีการ: *เก็บข้อมูลทั่วไปและปริมาตรลมรั่วผ่านกระเปาะลม จากผู้ป่วยใส่ท่อช่วยหายใจที่มีแผนถอดท่อ สังเกตและระบุหาภาวะหายใจเสียงครางหลังถอดท่อช่วยหายใจ*

ผลการศึกษา: *ผู้ป่วยทั้งหมด 115 คน พบว่ากำหนดค่าจุดตัดของปริมาตรลมรั่วผ่านกระเปาะลมน้อยกว่า 114 มิลลิลิตร ช่วยทำนายภาวะหายใจเสียงครางหลังถอดท่อช่วยหายใจที่มีความไวร้อยละ 89 ความจำเพาะร้อยละ 90 คุณค่าทำนายผลบวกร้อยละ 65 และคุณค่าทำนายผลลบร้อยละ 98 ตามลำดับ ในกลุ่มผู้ป่วยที่มีภาวะหายใจเสียงครางหลังถอดท่อช่วยหายใจ 12 ใน 19 คน ต้องใส่ท่อช่วยหายใจซ้ำ (ร้อยละ 63.2)*

สรุป: *ปริมาตรลมรั่วผ่านกระเปาะลมน้อยกว่า 114 มิลลิลิตร สามารถใช้เป็นตัวทำนายคลินิกตัวหนึ่ง สำหรับการระบุหาภาวะหายใจเสียงครางหลังถอดท่อช่วยหายใจ*