Associations between Male Gender, Body Size and Dimension of the Epiglottis

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July 2, 2020

Abstract

Objective: This prospective observational study aims to measure the epiglottic thickness by ultrasonography (US) in healthy volunteers. Methods: Healthy adult volunteers were recruited from the National Taiwan University Hospital between October and November 2019. Exclusion criteria included preexisting airway diseases, neck tumors, and a history of neck operation. Epiglottic thickness was measured at the midpoint, right and left edges of the epiglottis. Age, sex, height, weight, and body mass index (BMI) were collected. The linear regression model was employed to identify parameters to be associated with the epiglottic thickness. Coefficients and 95% confidence intervals (CIs) were computed. The literature was also reviewed. Results: There were 124 Chinese adults and 63 were men. The average age was 32.5±10.4 years. The midpoint, right edge and left edge of the epiglottic thickness was 2.03±0.42 mm, 2.14±0.42 mm and 2.21±0.42 mm, respectively. Male gender (midpoint, coefficient, 0.38, 95% CI, 0.35-0.43; right edge, coefficient, 0.33, 95% CI, 0.31-0.35; left edge, coefficient, 0.31, 95% CI, 0.29-0.35) and BMI (midpoint, coefficient, 0.02, 95% CI, 0.019-0.021; right edge, coefficient, 0.02, 95% CI, 0.019-0.022; left edge, coefficient, 0.02, 95% CI, 0.018-0.022) were associated with the epiglottic thickness. The epiglottis was thinner in normal Chinese adults, compared with that in Americans in the literature. Conclusions: US allows the depiction and assessment of the epiglottis in healthy volunteers. Male gender and higher BMI are associated with a thicker epiglottis. Future studies are warranted to evaluate race differences in the dimension of the epiglottic thickness.

Keywords:

Epiglottic thickness; ultrasonography; gender; body mass index

Key points:

1. Acute epiglottitis has become a disease of adults and ultrasonography can be an adjunct for diagnosis. However, the normal value of the dimension of the epiglottis was lacking.

2. Male gender and higher BMI are associated with a thicker epiglottis in Chinese healthy adults.

3. The Chinese adults have a relatively thinner epiglottis, compared with that in American.

Introduction

Acute epiglottitis is a supraglottic inflammatory disease, potentially causing life-threatening airway obstruction[1]. The most commonpathogen was *HaemophilusInfluenzae* type b (Hib). As a result of the introduction and widespread dissemination of the Hib vaccine in the 1980s, the incidence of epiglottitis in the pediatric population has dramatically dropped[2,3]. However, acute epiglottitis has become a disease of adultsin the post-vaccine era, approximately 4,000 new cases per year reported in the United States[4]. The mortality rates were reported from 1% to 7%[5,6]. Therefore, early recognition and accurate diagnosis for adult patients are required in emergency settings.

The diagnosisof acute epiglottitis is based on clinical symptoms, radiography, and laryngoscopy examination[7,8]. Sore throat and odynophagia are the common symptoms[5]. Laryngoscopy is regarded as thegold standard for diagnosis[9].However,laryngoscopy has limitations, suchas invasiveness, inconvenience, and procedure-related airway obstruction[10].During the COVID-19 pandemic, it represents aninfection risk for patients and a high occupational hazard for otolaryngologists involved with the procedure[11]. Also, less than 10% of patients with acute epiglottitis received laryngoscopy in a large-scale study[5]. Lateral neck-radiographs are oftenused for screening in emergency departments (EDs) for suspectedacute epiglottitis[12]. However, sensitivity andspecificity vary[9,13,14].

Ultrasonography (US) is a real-time, noninvasive, readily accessible imaging diagnostic tool in the EDs.Previous studies showed that the epiglottis couldbe identified and measured by US[15-17]. However, data on the epiglottic thickness in normal individuals are still limited[15,18].

Werner *et al* reported that epiglottic thickness in a mixed population including ED staff members and patients[15]. However, the anteroposterior diameter of the epiglottis was significantly different between healthy volunteers and patients, especially in those with inflammation[18]. Establishing the range of normal values of the epiglottic thickness is mandatory for differentiating between the normal and abnormal epiglottis and for serving as a reference for other pathologies. Whether the epiglotticthickness varies according to raceethnicity is uncertain.

Therefore, we conducted a prospective observational study to investigate the epiglottic thicknessmeasured by US in healthy volunteers.

Methods

Study design and participant enrollment

The study wasa prospective observational study.Volunteers were recruited from [removed for blind peer review] between October and November 2019. It was approved by the institutional review board of the hospital (201910015RINC) and registered at ClinicalTrials.gov (NCT04175483).

The enrollment document was publicly available on bulletin boards for 1 month before the recruitment. Healthy volunteers aged more than 20 years were included in this study. Exclusion criteria included preexisting airway obstruction, or respiratory diseases such as asthma and chronic obstructive pulmonary disease, neck tumors, and a history of neck operation or smoking. An independent investigator, who was not involved in measurement and data analysis, recruited volunteers.Written informed consent wasobtained from each participant.

Measurements of the epiglottic thickness

A SSA-780A ultrasound scanner (Canon, Japan) equipped with a 7-12 MHz linear transducer was used. Participants lied in the supine position with their neckextended slightly. The sonographers identified the thyroid and cricoid cartilage and gently moved the linear probe superiorly. After tilting the probe, the epiglottis appeared (Figure 1). The epiglottic thickness was determined at three sites: midpoint, right edge, and left edge. The thickness on each edge was determined at a fixed distance from the midpoint[18].

The epiglottic thickness was measured by two independent physicians who were well-instructed and qualified for airway US after a 1-h standard lecture and 8-h hands-on practice. Each sonographer measured the epiglottic thickness at each site for three times. The measurements were supervised and confirmed by a senior physician with more than 10 years of experience in sonographic examinations and certification from the Society of Ultrasound in Medicine (Blinded for review).

Data collection

The following parameters of the participants were recorded at the time of the study by an independent investigator: age, sex, weight, height, and BMI.BMI was calculated as body weight divided by the square of the body height. Also, literature was reviewed for the sonographic epiglottic thickness in healthy subjects for potential race differences.

Statistical analysis

The sample size was estimated by using PASS 2019 software (NCSS software, Kaysville, Utah, USA). The sample size was calculated to be at least 112 to achieve a power of 0.9 under the significance level of 5%. Cohen's kappa statistic (K) was calculated, which reflected the inter-rater reliability for the measurements.

Participant data weredeidentified before data cleaning and statistical analysis.All data were analyzed by SAS software (SAS 9.4, Cary, North Carolina, USA). Student t-test was used for continuous data and the Chi-square test was used for categorical variables. A p-value of less than 0.05 was considered significant. Linear regression models were employed to identify parameters to be associated with the epiglottic thickness significantly and independently. Covariates in the model were age, sex, height, weight, and BMI. Coefficients and 95% confidence intervals (CIs) were computed.

Results

There were 127 volunteers eligible in this study. After exclusion, a total of 124 Chinese volunteers were included (Figure 2). Of them, 63 (51%) were men. The average age was 32.5±10.4 years, ranging from 19 to 74 years. The average BMI was 23.1±4.0 Kg/m^2, ranging from 15.0 to 35.4 Kg/m^2. The average thickness of the midpoint, right edge,and left edge of the epiglottis was 2.03±0.42, 2.14±0.42,and 2.21±0.42 mm, respectively. The K value was 0.87 for inter-rater reliability.

The midpoint, right edge and left edge of the epiglottis were thicker in men than in women ($p<0.001$, Table 1). Besides, epiglottic thickness differed between different body sizes($p=0.0017$). Table 2 presents the dimensions categorized by BMI. It was divided into four groups based on the World Health Organization classification of BMI[19]: underweight ([?]18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese ([?]30.0 kg/m^2).Participants with higher BMI had increased thickness of epiglottis that obese participants had an approximately 20% thicker epiglottis than normal-weight participants.

Linear regression models were used to investigate the factor associated with the epiglottic thickness. Male gender (midpoint, coefficient, 0.38, 95% CI, 0.35-0.43; right edge, coefficient, 0.33, 95% CI, 0.31-0.35; left edge, coefficient, 0.31, 95% CI, 0.29-0.35) and BMI (midpoint, coefficient, 0.02, 95% CI, 0.019-0.021; right edge, coefficient, 0.02, 95% CI, 0.019-0.022; left edge, coefficient, 0.02, 95% CI, 0.018-0.022) were associated with the epiglottic thickness.

Table 3 lists the results of a comprehensive literature reviewof the epiglottic thickness measured by US in healthy subjects. The epiglottis was relatively thin in the Chinese population.

Discussion

This study evaluated the epiglotticthickness measured by US in healthy Chinese adults. The results showed that male gender and higher BMI were positively related to the thicker epiglottis. Also, Chinese adults had thinner epiglottisthan Americans[15].

US is a real-time, noninvasive, non-radiated, readily accessible imaging modality. With such characteristics, US can play an important role in screening and diagnosis in the EDs.It has a wide range of applications such as cardiopulmonary resuscitation, shock evaluation, and airway management[20-22]. This study demonstrates the feasibility of US for evaluation of the epiglottis. It could be a supplementary examination for patients with suspected acute epiglottitis, in addition to conventional radiography. Also, it would be more suitable than laryngoscopy during the COVID-19 pandemic. Moreover, US had a greater value for patients having hemodynamic instability or severe dyspnea in difficulties to obtain optimal radiographs[18].

Evidence regarding US evaluation of epiglottis for healthy adults is still limited. Werner *et al* reported thickness among the normal American subjects and patients[15]. Ko*et al* have reported the sonographic thickness of the epiglottis among Korean adults[18]. Comparing with their results, this studyshowed the epiglottisin healthy Chinese adults was thinner than that in Americans.

The current study provides comparability between genders that the numbers of men and women were approximately equal.Also, it not only included obese volunteers but also stratified them according to their BMI. The results showed male gender and higher BMI were independent predictors for the epiglotticthickness, although gender had a greater impact.Reviewing the literature, menhave been reported to have a thicker epiglottis than women[15,23]. Male gender and BMI>25.0 kg/m2were significantly associated with severe epiglottitis[24]. Whether thicker epiglottis related to a higher incidence of epiglottitis in men[5,9,25] is uncertain. Moreover, whether thicker epiglottis in men and subjects with higher BMI has more chances to develop severe epiglottitis needs further investigation.

To the best of our knowledge, this is the first study to investigate the epiglottic thickness in healthy Chinese adults. Independent predictors such as gender and BMI were identified. Race ethnicity would exist in the epiglottic thickness.

Despite these contributions, this study has several limitations. First, the results were obtained from one single institution. However, the sample size and the power of the study were statistically sufficient. Second, US is an operator-dependent imaging modality. The bias could be eliminated through supervision by a senior instructor. Additionally, Cohen's kappa in the current study was 0.87, which implied good consistency between operators for the epiglottic measurements. Third, data regarding race-ethnicity were obtained from previous studies. Future multicenteror international studieswould be conducted for validation or investigation for race differences.

Conclusion

This prospective study demonstrates the feasibility of US for evaluation of the epiglottis. It provides the normal values of the dimension of the epiglottis in healthy Chinese adults. Male gender and higher BMI are associated with a thicker epiglottis. The epiglottis was thinner in Chinese than that among Americans. However, future multicenter and international studies would be conducted to determine race differences.

Conflict of interest:

The authors declare no conflicts of interest for this article.

Ethical approval:

The study was authorized by the Ethics Committee of the National [Blinded for review] University Hospital, and the written informed consent for this study was obtained from the participants.

Data availability statement:

All data generated or analysed during this study are included in this article.

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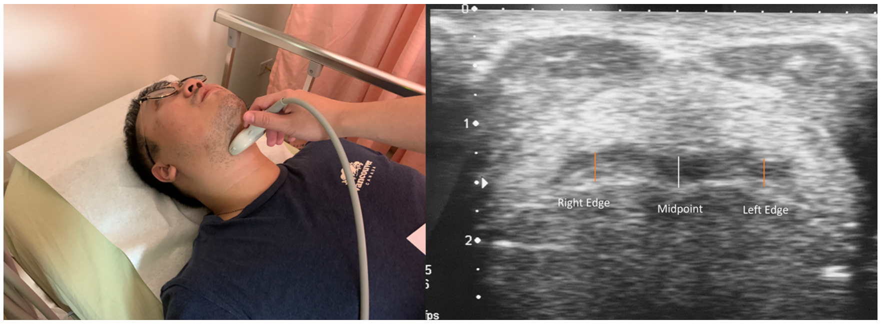
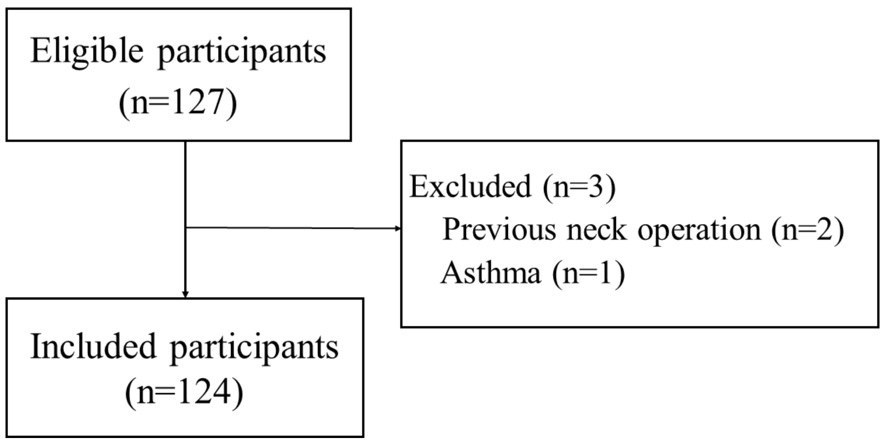
Figure legends

Fig 1. The thickness of the epiglottis. Left panel, the patient lies supine with neck slightly extension. The probe is transversely positioned at the subglottic region; Right panel, the measurement of the epiglottic thickness at the midpoint, right edge, and left edge.

Fig 2. The study flow diagram.





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