Evaluation of Normal Epiglottis on Computed Tomography with Special Attention to Thickness

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Abstract

To our knowledge, this is the first study to investigate the thickness of the normal epiglottis on computed tomography (CT) in a Japanese population. The focus was on determining the thickness of a normal epiglottis, which could then serve as a reference in detecting abnormalities. We believe that this would facilitate diagnosing and determining the extent of cancerous invasion of the supraglottis and secondary invasion of the epiglottis. This retrospective study was based on a review of radiographic data in patient charts. Cervical CT scans obtained from 79 Japanese patients (44 men [55.7%] and 35 women [44.3%]; age range, 28–85 years; mean, 58.9 years) showing a normal epiglottis under laryngoscopy were evaluated. The thickness of the epiglottis was measured on CT scans and the results analyzed with the Student’s t-test, an analysis of variance, and the Tukey-Kramer test. The epiglottis in men was significantly thicker than that in women (p<0.05). A statistically significant difference was observed in thickness depending on longitudinal height (p<0.001). The thickness at the median was larger than that bilaterally in all patients (p<0.001). No statistically significant difference was observed in thickness depending on side or age. The thickness of the normal epiglottis was established at each level. We believe that these data could serve as a reference in diagnosing and detecting abnormalities of the epiglottis.

Key words: Epiglottis — Thickness — Computed tomography

Introduction

The larynx is divided into 3 regions: the supraglottis, the glottis, and the subglottis. The supraglottis is composed of the epiglottis, aryepiglottic fold, arytenoids, and ventricular band. For staging purposes, the epiglottis is split into a supra- and infrahyoid portion by a
plane located at the level of the hyoid bone. The normal morphological features of the epiglottis have received little attention in the literature. A number of studies have investigated the thickness of the anatomical epiglottis based on cadavers or sonographic evidence. To our knowledge, however, no study to date has investigated the thickness of the normal epiglottis based on evidence from computed tomography (CT). Nonetheless, it has been noted that increasing use of CT in obtaining a work-up on patients with globus sensation or dysphagia, or when screening of head and neck malignancies, indicates the need for more detailed knowledge of the morphology of the normal epiglottis. The clinical diagnosis of cancer of the epiglottis is based on laryngoscopic evaluation of its morphology. Meanwhile, radiological diagnosis of epiglottal abnormalities based on CT data focuses on its morphology, including its thickness. Therefore, it is important to establish the normal anatomy of the epiglottis on CT images, particularly with regard to its thickness. This would allow greater reliability with regard to diagnosing and determining the extent of cancerous invasion of the supraglottis and secondary invasion of the epiglottis.

The purpose of this study was to determine the normal thickness of the epiglottis in the Japanese population. We believe that this would allow more accurate diagnosis and detection of abnormalities of the epiglottis.

**Materials and Methods**

This retrospective study was approved by the Research Ethics Committee of the Tokyo Dental Collage Ichikawa General Hospital (Approval number: I 15–16). The requirement for informed consent was waived. Seventy-nine cervical CT scans obtained from 79 Japanese patients between April 1, 2013 and March 31, 2014 were evaluated.

The inclusion criteria comprised the following: globus sensation or dysphagia; no medical history of head or neck malignancies; and no surgery or other treatment for laryngopharyngeal problems. All the patients underwent laryngoscopy, the findings of which showed a normal epiglottis.

The examinations were performed with a 64-section multidetector CT scanner, the model Aquilion ONE (Toshiba Medical Systems, Tokyo, Japan) under the following standard protocol: 64 × 0.625-mm collimation with 0.5 mm-thick sections; 2-mm reconstruction; and a pitch of 0.942. The Picture Archiving and Communication System (Synapse Viewer; Fuji Medical Systems, Tokyo, Japan) was used for viewing and evaluating the scans digitally. All the CT scans in this study were performed with the patient in the dorsal position so that the dental arch was perpendicular to the bed. The patient was instructed to keep their mouth closed and refrain from swallowing during scanning. The study protocol at this hospital mandates the use of intravenous contrast medium for CT examination. Therefore, all imaging was performed under contrast-enhanced conditions, allowing for a unified study setting. Axial CT images were also reconstructed for each patient parallel to the line along the fourth/fifth cervical disc-space, which is adequate for evaluation of laryngeal cancer. The position of the larynx in all the images obtained was confirmed to be suitable to allow adequate evaluation. The thickness of the epiglottis was determined on the axial images. To standardize the assessments, 3 respective levels were defined based on sagittal images: the hyoid level, situated along the line parallel to the superior margin of the hyoid bone; the suprahypoid level, situated 4 mm higher than the hyoid level; and the infrayiod level, situated 4 mm lower than the hyoid level. Thickness was determined at 3 locations at each level: the median, the right side, and the left side (Figs. 1–3). Thickness on each side was determined at a point 5 mm from the median as follows: first, the median line was taken; then, a distance of 5 mm was measured along the major axis of each epiglottic fold from the center of median line; and finally thickness was measured as the minor axis of that location (Figs. 1–4). An
appropriate window setting was used in measuring the thickness of the epiglottis on CT. Measurements were recorded to the first decimal place in millimeters. The mean, standard deviation (SD), and range were calculated for each portion. All statistical analyses were performed with BellCurve for Excel (SSRI, Tokyo, Japan). The Shapiro-Wilk test showed that the distribution of all data was normal. The Student’s t-test was used to evaluate thickness between sexes. An analysis of variance and the Tukey-Kramer test were used to evaluate thickness between the 9 regions of the epiglottis and between different ages. Finally, additional data on a patient with cancer of the epiglottis were used as a comparison to validate our conclusions.

Fig. 1 Thickness of epiglottis at hyoid level
Sagittal contrast-enhanced CT image at hyoid level demonstrates line plane defined for transverse CT examination (a; white line). Transverse contrast-enhanced CT image in air tissue window at hyoid level demonstrates transverse shape of epiglottis; line represents diameter of thickness of epiglottis (b; bi-directional arrows).

Fig. 2 Thickness of epiglottis at suprahyoid level
Sagittal contrast-enhanced CT image at suprahyoid level demonstrates line plane defined for transverse CT examination (a; white line). Transverse contrast-enhanced CT image in air tissue window at suprahyoid level demonstrates transverse shape of epiglottis; line represents diameter of thickness of epiglottis (b; bi-directional arrows).

Fig. 3 Thickness of epiglottis at infrahyoid level
Sagittal contrast-enhanced CT image at infrahyoid level demonstrates line plane defined for transverse CT examination (a; white line). Transverse contrast-enhanced CT image in air tissue window at infrahyoid level demonstrates transverse shape of epiglottis; line represents diameter of thickness of epiglottis (b; bi-directional arrows).

Fig. 4 Criteria for measurement of epiglottis thickness along median and lateral line
A: Major axis of left epiglottic fold.
B: Minor axis of left epiglottic fold.
C: Thickness of median line.
D: Thickness of left line.
Results

A total of 79 patients (44 men [55.7%] and 35 women [44.3%]; age range, 28–85 years; mean age [± SD], 58.9 ± 14 years) were evaluated. The mean thickness ± SD and the lower and upper normal limit of the normal epiglottis in each sub-region in all patients on multi-detector CT is described in Table 1.

The mean thickness ± SD in men and women patients is shown in Tables 2 and 3. The epiglottis was thicker in men than in women at any level and in any respective portion (p-value ranging from 0.028 to <0.001). The epiglottis was thicker at the lower levels. This result was significantly consistent in all median, right, and left portions (p < 0.001). No statistically significant differences were observed in thickness between the right and left sides at any level (p = 0.99–1.00). Thickness at the median was larger than that bilaterally in all patients (p < 0.001). No statistically significant difference in thickness was observed in relation to age (p = 0.75–1.00).

The CT image of the one patient with proven cancer of the epiglottis showed a significantly greater thickness than that which would be considered normal.

Discussion

Computed tomography can sometimes allow detection of occult malignancies of the epiglottis and help determine whether cancer of the supraglottis has invaded the epiglottis. The key findings for cancer of the supraglottis on evidence from CT are mainly related to shape, including thickness. To the best of our knowledge, however, no studies to date have investigated the thickness of the normal epiglottis on CT.

The present results indicate that an additional 2SDs would indicate abnormal thickness of the epiglottis. Therefore, we believe that normal thickness should be taken as less than 5.5 mm in the median portion at the suprahyoid level and 3.4 mm bilaterally. In the same manner, normal thickness at the hyoid level should be less than 6.5 mm along the median line, and 4.4 mm on the left and right sides, while at the infrahyoid level, it should be 8.7 mm and 7.7 mm, respectively.

To verify these results, they were compared with those from a case of pathologically proven cancer of the epiglottis on the left side on a transverse contrast-enhanced CT image at the hyoid level (Fig. 5). The thickness of the epiglottis in the median line on this image was 4.5 mm, with 3.1 mm on the right and 8.6 mm on the left. Thus, there was significantly greater thickness in this patient than that which would be considered normal based on the present results. Therefore, the thickness on the left side would have been taken to indicate an abnormality requiring further investigation.

The normal epiglottis showed greater thickness at the median line than the bilateral aryepiglottic folds at all levels, regardless of

| Table 1 | Thickness of epiglottis on transverse contrast-enhanced CT in all patients |
|---------|-------------------------------|-------------------------------|-------------------------------|
| Measurement (mm) | Right | Median | Left |
| Suprahyoid Level | 2.4 ± 0.5 [4.3–1.3] | 3.8 ± 0.8 [6.0–1.8] | 2.4 ± 0.5 [4.0–1.4] |
| Hyoid Level | 3.1 ± 0.6 [4.4–1.9] | 4.7 ± 0.9 [7.3–0.5] | 3.1 ± 0.7 [4.9–1.8] |
| Infrahyoid Level | 5.2 ± 1.2 [7.5–2.1] | 6.3 ± 1.2 [9.6–1.8] | 5.2 ± 1.2 [7.6–2.7] |

Note. —Data represent average thickness ± SD and upper and lower normal limit in millimeters
Table 2  Thickness of epiglottis on transverse contrast-enhanced CT in men

| Measurement (mm)     | Right       | Median      | Left        |
|----------------------|-------------|-------------|-------------|
| Suprahypod Level     | 2.6 ± 0.5   | 4.2 ± 0.8   | 2.6 ± 0.5   |
| Hyoid Level          | 3.3 ± 0.6   | 5.1 ± 0.7   | 3.6 ± 0.7   |
| Infrahypod Level     | 5.8 ± 1.1   | 6.7 ± 1.1   | 5.9 ± 1.1   |

Note. —Data represent average thickness ± SD in millimeters

Table 3  Thickness of epiglottis on transverse contrast-enhanced CT in women

| Measurement (mm)     | Right       | Median      | Left        |
|----------------------|-------------|-------------|-------------|
| Suprahypod Level     | 2.2 ± 0.4   | 3.2 ± 0.7   | 2.2 ± 0.4   |
| Hyoid Level          | 2.8 ± 0.5   | 4.3 ± 0.1   | 2.9 ± 0.6   |
| Infrahypod Level     | 4.7 ± 1.1   | 6.0 ± 1.0   | 4.6 ± 0.9   |

Note. —Data represent average thickness ± SD in millimeters

Fig. 5  Case of epiglottis cancer on left side

Man in his 70s with epiglottis cancer. Transverse contrast-enhanced CT image at hyoid level showed mass lesion centered on epiglottis on left side (arrow) pathologically proven to be case of squamous cell cancer. Measurement of epiglottis on left side revealed significantly greater thickness than mean value ± 2SD; epiglottis on right side showed normal thickness and morphology.

sex. The epiglottis was also larger at the lower level. These findings reflect the normal morphology of the epiglottis, which tapers along the craniocaudal axis.

The thickness of the epiglottis showed a relatively low SD in all locations, which supports the accuracy of the measurements obtained. This also indicates that deviation from normal could therefore act as a powerful indicator of abnormality.

A more detailed analysis revealed a statistically significant difference depending on sex, with the mean thickness in men significantly greater than that in women (4.23 and 3.23 mm, respectively). In an earlier ultrasound study, the epiglottis was also significantly thicker in men than in women (2.49 and 2.34 mm, respectively), a finding which the present results support. Another study using cadavers also found that this value was greater in men, although no statistical evaluation was performed (mean of 5.13 mm in men versus 4.37 mm in women).

The radiological thickness of the epiglottis at the median at the suprahypoid level in the present study was relatively close to the anatomical thickness of the epiglottis (at the level of base of the glossal and median aspects of the epiglottis) reported previously in cadavers. The anatomical thickness of the epiglottis in both men and women was larger than radiological thickness, with a mean difference of 0.9 mm in men and 1.14 mm in women. These differences might have been due to swelling in the cadavers, which were dissected at approximately 24 hours post-mortem. In the present study, no differences were found in radiological thickness depending on age. This result is in disagreement with that of an earlier report, which noted that thickness increased with age.

There were some differences between the present results and those of Werner et al. We believe that these may have been due to differences in the modalities and/or measurement angles adopted. In their ultrasound study, the thickness of the epiglottis was evaluated in the median of the transverse view at the estimated level, which is equivalent to the infrahypoid level in the present study. They found that the mean thickness of the epiglott-
The thickness of the epiglottis on CT was analyzed retrospectively in 79 patients in this study. The results revealed what we believe represents the normal thickness value. We believe that this should help enable clinicians to more accurately diagnose and detect abnormalities of the epiglottis, including cancer, and that this could also be useful in evaluating invasion of the infrahyoid epiglottis.

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