ORİJİNAL MAKALE / ORIGINAL ARTICLE

Balıkesir Sağlık Bilimleri Dergisi / BAUN Sağ Bil Derg
Balıkesir Health Sciences Journal / BAUN Health Sci J
ISSN: 2146-9601- e ISSN: 2147-2238
Doi: https://doi.org/10.53424/balikesirsbd.1180892

Evaluation of Epiglottic Cartilage Morphometry Using Magnetic Resonance Imaging

Esma DERİNÖZ[1], Alper VATANSEVER[2], Bahar YANIK KEYİK[3], Emrah ÖZCAN[1], İlter KUŞ[1]

[1] Balikesir University, Faculty of Medicine, Department of Anatomy
[2] Bursa Uludag University, Faculty of Medicine, Department of Anatomy
[3] Balikesir University, Faculty of Medicine, Department of Radiology

Geliş Tarihi / Received: *27.09.2022,* ***Kabul Tarihi / Accepted:*** *11.11.2022*

ABSTRACT

Objective: Epiglottic cartilage (EC) is an important larynx cartilage with elastic cartilage structure. Functionally, this structure, which acts as a gate between the larynx and the pharynx, can be damaged due to difficult intubation during the advancement of the endotracheal tube. The aim of this study; EC's morphometric relationship with the surrounding anatomical structures is to be examined and to minimize the complications that occur in clinical applications in line with the data obtained. **Materials and Methods:** In the study, cervical MRI series of 79 females and 53 males aged 20 years and older were obtained from Balikesir University PACS system archive and analysed retrospectively. The morphometric analysis of the obtained images was carried out by transferring them to the Radiant DICOM Viewer software. In the study, the distance of EC to the surrounding anatomical structures, the angle of the visceral region between the stalk of epiglottis (SE) and the thyroid cartilage (ThC), and the lengths of the fixed and free part of EC were evaluated. The data evaluated in the study were statistically analysed using SPSS software. **Results:** The length values analysed statistically in the study tended to be higher in male individuals than in female individuals. However, It was observed that the visceral region angle between SE and (ThC) tended to be higher in female individuals than in male individuals. Age and larynx length (LL), the distance of apex part of epiglottic cartilage (AEC) to root of tongue (RT), and the length of the free part of epiglottic cartilage (FEC) showed a positive correlation. The mean length of larynx was 2.45±0.53 cm according to the determined reference points. **Conclusion:** As a result of the values reached, clinicians will be able to have an idea about the distance of AEC to RT by measuring the LL with palpation just before endotracheal intubation. Based on this, it is thought that possible EC injuries can be prevented by predicting difficult intubation.

Keywords: Epiglottic Cartilage, Endotracheal Intubation, Larynx, Morphometry, MRI.

Cartilago Epiglottica Morfometrisinin Manyetik Rezonans Görüntüleme ile Değerlendirilmesi

ÖZ

Amaç: Cartilago epiglottica (CE), elastik kıkırdak yapısına sahip olan önemli bir larynx kıkırdağıdır. Fonksiyonel olarak larynx ve pharynx arasında bir kapı görevi gören bu yapı, endotrakeal tüpün ilerletilmesi sırasında zor entübasyon sebebiyle zarar görebilmektedir. Bu çalışmanın amacı; CE'nın çevre anatomik yapılar ile arasındaki morfometrik ilişkisinin incelenerek, elde edilen veriler doğrultusunda klinik uygulamalarda meydana gelen komplikasyonların en aza indirgenebilmesini sağlamaktır. **Gereç ve Yöntem:** Çalışmada, 20 yaş ve üzerindeki 79 kadın ve 53 erkek bireyin servikal MR serileri Balıkesir Üniversitesi PACS sistemi arşivinden temin edilerek retrospektif olarak incelendi. Elde edilen görüntülerin morfometrik analizi Radiant DICOM Viewer yazılımına aktarılarak gerçekleştirildi. Çalışmada, CE'nın çevre anatomik yapılara olan mesafesi, petiolus epiglottidis (PE) ile cartilago thyroidea (CTh) arasındaki visseral bölge açısı ve cartilago epiglottica'nın fikse (CEF) ve serbest (CES) kısmının uzunlukları değerlendirildi. Çalışmada değerlendirilen veriler SPSS yazılımı kullanılarak istatistiksel olarak analiz edildi. **Bulgular:** Çalışmada istatistiksel olarak analiz edilen uzunluk değerleri, erkek bireylerde kadın bireylere oranla fazla olma eğilimindeydi. Ancak; PE ile CTh arasındaki visseral bölge açısının, kadın bireylerde erkek bireylere oranla fazla olma eğiliminde olduğu görüldü. Yaş ile larynx uzunluğu (LU), CEA kısmının radix linguae'ya (RL) olan mesafesi ve CES kısmının uzunluğu pozitif yönlü korelasyon gösterdi. Belirlenen referans noktalarına göre LU, ort. 2.45±0.53 cm idi. **Sonuç:** Klinisyenler ulaşılan değerler sonucunda, endotrakeal entübasyondan hemen önce LU'nu palpasyonla ölçerek CEA kısmının RL'ya olan uzaklığı hakkında bir fikir sahibi olabileceklerdir. Buna istinaden zor entübasyonun öngörülmesiyle olası CE yaralanmalarının önüne geçilebileceği düşünülmektedir.

Anahtar Kelimeler: Cartilago Epiglottica, Endotrakeal Entübasyon, Larynx, Morfometri, MRG.

Sorumlu Yazar / Corresponding Author: Esma DERİNÖZ, Balikesir University, Faculty of Medicine, Department of Anatomy, Balikesir, Turkey
E-mail: esderinoz@gmail.com

Bu makaleye atıf yapmak için / Cite this article: Derinoz, E., Vatansever, A., Keyik, B. Y., Ozcan, E. & Kus, I. (2023). Evaluation of epiglottic cartilage morphometry using magnetic resonance imaging. *BAUN Health Sci J, 12(1): 46-51.* https://doi.org/10.53424/balikesirsbd.1180892.

INTRODUCTION

EC is an important laryngeal cartilage that is encountered during intubation applications and should be considered during transitions. In difficult intubation, it may fold, edema may occur, and even injury may cause hematoma. Due to these iatrogenic injuries, which are unusual complications for anaesthesiologists, patients experience symptoms such as severe sore throat, hoarseness and dysphagia. These symptoms negatively affect the life quality of patients and reveal the clinical importance of EC (Hatzakorzian et al., 2006; Lin et al., 2004; Van Zundert and Wyssusek, 2018).

In the literature, there are studies in which the EC was examined morphometrically. In those studies, morphometric properties of the EC such as length, width and thickness were evaluated (Ajmani, 1990; Baba et al., 2019; Joshi et al., 2011; Poornima and Dakshayini, 2017; Sprinzl et al., 1999). Additionally, there were radiologic studies using ultrasound and computed tomography (CT) that examined the EC (Baba et al., 2019; Joshi et al., 2011; Mohammadi et al., 2020; Poornima and Dakshayini, 2017; Sprinzl et al., 1999). However, studies using magnetic resonance imaging (MRI) series to evaluate EC morphometry were limited.

Morphometric data revealed by other morphometric studies focusing EC may need to improve for demonstrate morphometric properties of EC in more detail. Knowing these properties is of great importance for clinicians in terms of preventing EC injuries that may occur during endotracheal intubation.

The aim of this study was obtain morphometric data using MRI series. Thus, these radiologic data could be used as a guide for clinicians while clinical applications.

MATERIALS AND METHODS

Participants

This study was completed using MRI series of head and neck region of participants who applied to radiology department for various reasons, retrospectively. The MRI series were obtained from Picture Archiving and Communication Systems (PACS) of radiology department of our university's hospital. A total number of 132 (79 women / 53 men) participants (age between 24-91; mean age 53.07±14.29) MRI series evaluated. Participants who had sleep apnea, history of surgery and trauma against larynx and neck region, having any pathologies and closed EC were excluded from study.

Image acquisition

MRI was performed using a 1.5 T MR device (Philips, Ingenia, 2013). Anatomical images were obtained with T2-weighted cervical MRI series in the sagittal and axial planes. Parameter setting in T2 weighted series in sagittal plane; TR: 3000-4000 / TE: 110, FOV: 160 mm, NEX: 2-5, thickness: 3 mm, cross section spacing: 0.3 mm. Parameter setting in T2 weighted series in the axial plane; TR: 3000-5000 / TE: 110, FOV: 130 mm, NEX: 3, thickness: 3-5 mm, cross section spacing: 0.35 mm.

Obtained images were transferred to Radiant DICOM Viewer 64-bit computer software and evaluated quantitatively. Morphometric measurements were completed in the sections which had the best appearance of the epiglottic and thyroid cartilages in sagittal and axial images.

Morphometric parameters

In our study, morphometric parameters were evaluated using sagittal sections.

In the sagittal section, distance from AEC to RT (cm) (Figure 1), length of fixed (Figure 2) and free (Figure 3) part of EC (cm), with ThC angle (degrees) facing visceral surface between SE (Figure 4) and LL (cm) were measured (Figure 5). Clinically palpable landmarks, laryngeal prominence and lower border of cricoid cartilage, were selected for measuring length of larynx. Lower edge of the cricoid cartilage was identified in axial sections, then distance between laryngeal prominence and cricoid cartilage was measured in sagittal sections.

Statistical analyses

Statistical analyses of data evaluated in presented study were performed using SPSS version 25. The suitability of data to normal distribution was tested analytically with Kolmogorov-Smirnov, visually with histogram and probability plots.

Independent group t-test was used to compare the normally distributed variables between the groups. Mann-Whitney U test was used to compare the non-normally distributed variables between the groups. With this test, it was investigated whether there were significant relationships between the variables.

In our study, correlation analysis of all variables was performed without considering gender, and their relations with each other were examined. Because the variables did not have a normal distribution, "Spearman's Rho" test was used for correlation analysis. In the test, cases where the p value was less than 0.05 were considered statistically significant (Hayran and Hayran; 2011).

Ethical considerations

This study was begun after getting approval from Balikesir University Faculty of Medicine Non-Invasive Clinical Research Ethics Committee (Decree No: EK-2021-153).

Figure 1. Distance of epiglottic cartilage to root of tongue.

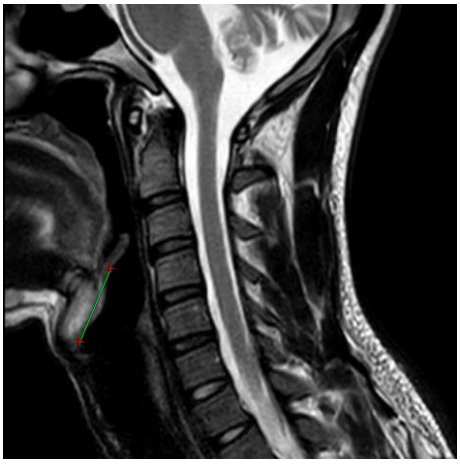

Figure 2. Length of the fixed portion of epiglottic cartilage.

Figure 3. Length of the free part of epiglottic cartilage.

Figure 4. Angle facing the visceral region between the thyroid cartilage and the stalk of epiglottis.

Figure 5. Larynx length.

RESULTS

Morphometric measurements

The descriptive values of the variables were summarized below.

The distance between AEC and RT was 0.44±0.35 cm, the length of fixed part of epiglottic cart. was 2.10±0.66 cm, the length of free part of epiglottic cartilage was 1.65±0.40 cm, facing the visceral surface between ThC and SE angle was 113.5±11.08 degrees and LL was 2.45±0.53 cm.

Gender differences

The distance from AEC to RT ($p< 0.001$), the length of fixed part of epiglottic cartilage ($p<0.001$), the length of free part of epiglottic cartilage ($p\leq0.001$) and the length of larynx ($p<0.001$) were tended to be longer in men. The angle between SE and ThC tended to be higher in women ($p<0.001$).

Correlation analysis

According to our results; It was determined that there was a weak positive correlation ($p=0.03$) ($r=0.191$) between the distance from AEC to RT and the length of larynx. The results of the correlation analysis of the variables without gender discrimination were demonstrated in Table 1.

Table 1. Correlation analysis without gender discrimination.

			Age	Distance of epiglottic cartilage to root of	Length of fixed part of epiglottic	Length of free part of epiglottic cartilage	Angle (degrees) facing the visceral	Larynx length (cm)
Spearman's rho	Age	r	1.000	0.185*	0.073	0.194*	0.126	0.244**
		p	.	0.034	0.404	0.026	0.151	0.005
		n	132	132	132	132	132	132
	Distance of epiglottic cartilage to root of tongue (cm)	r	0.185*	1.000	0.275**	0.039	-0.199*	0.191*
		p	0.034	.	0.001	0.653	0.022	0.028
		n	132	132	132	132	132	132
	Length of fixed part of epiglottic cartilage (cm)	r	0.073	0.275**	1.000	-0.135	-0.411**	0.355**
		p	0.404	0.001	.	0.124	0.000	0.000
		n	132	132	132	132	132	132
	Length of free part of epiglottic cartilage (cm)	r	0.194*	0.039	-0.135	1.000	-0.094	0.205*
		p	0.026	0.653	0.124	.	0.283	0.018
		n	132	132	132	132	132	132
	Angle (degrees) facing the visceral region between thyroid cartilage and stalk of epiglottis	r	0.126	-0.199*	-0.411**	-0.094	1.000	-0.114
		p	0.151	0.022	0.000	0.283	.	0.192
		n	132	132	132	132	132	132
	Larynx length (cm)	r	0.244**	0.191*	0.355**	0.205*	-0.114	1.000
		p	0.005	0.028	0.000	0.018	0.192	.
		n	132	132	132	132	132	132

**= Correlation is significant at the 0.01 level (2-tailed), *=Correlation is significant at the 0.05 level (2-tailed).

DISCUSSION

Epiglottic cartilage injuries occurring while endotracheal tube insertion following anaesthesia induction are an unusual complication for anaesthesiologists. Due to those unexpected iatrogenic injuries, patients experience symptoms such as severe sore throat, hoarseness, and dysphagia (Hatzakorzian et al., 2006; Lin et al., 2004; Van Zundert and Wyssusek, 2018). We aimed to evaluation the morphometric properties of EC and its relation with other structures in more detail. There are few studies focused to evaluate morphometric properties of EC on fresh cadavers using measuring instruments such as caliper (Ajmani, 1990; Joshi et al., 2011; Poornima and Dakshayini, 2017; Sprinzl et al., 1999). In these studies, EC morphometry was investigated with length and width parameters. Baba et al. (2019) completed a retrospective study on Japanese population using CT images that was aimed to investigate thickness of EC. The authors aimed to obtain data that could serve as a reference for detecting abnormalities in the thickness of EC. However, it is very difficult to evaluate uncalcified anatomic structures on CT images. Our study differs from other studies in terms of using MR images for morphometric evaluations. Cases such as folding, edema and hematoma occur in EC as a result of complications after endotracheal intubation were reported in recent studies (Hatzakorzian et al., 2006; Lin et al., 2004; Van Zundert and Wyssusek, 2018). In those studies, it was emphasized that the EC could be damaged during endotracheal intubation without regarding applied intubation method.

Mohammadi et al. (2020) have completed a morphometric study that aimed to evaluate skin – EC and EC – vocal ligament distances using ultrasound before intubation, then compared the data according to the Cormack-Lehane classification. As a result of their study, degree of difficulty while intubation increased with those distances. Thus, it has been reported that sonographic measurement criteria could be helpful in predicting difficulty level of intubation. However, due to the relationship between LL and EC evaluated in our study, difficult intubation could be evaluated by anaesthesiologists without requiring sonographic measurements.

Delakorda et al. (2019) investigated effects of different EC shapes on the degree of airway obstruction in patients with sleep apnea. As a result of their study, it was determined that the degree of obstruction was higher in sleep apnea patients with flat EC. However, in current and similar studies involving sleep apnea patients, morphometric relationship of epiglottic cart. with adjacent anatomical formations was not analysed (Catalfumo et al., 1998; Gazayerli et al., 2006; Li et al., 2014; Mohammadi et al., 2020; Torre et al., 2016). When parameters evaluated in our study were compared with other morphometric studies of EC it has been seen that the distance from AEC to RT, the length of fixed and free part of EC, the angle between SE and ThC, and the correlations of these morphometric measurements between each other were investigated for the first time. Moreover, the distance from laryngeal prominence and to lower border of cricoid cartilage, clinically palpable landmarks, were evaluated using MRI series in our study. Evaluating

morphometric properties of anatomical structures using easily palpable landmarks could be useful for material selecting criteria and completing more comfortable with less risk intubation. According to our results, the positive correlation between length of larynx and distance from AEC to RT could be a beneficial guide for physicians during endotracheal tube application. By palpating laryngeal prominence and cricoid cartilage during intubation, length of larynx could be evaluated and distance from AEC to RT could be predicted. Thus, EC injuries might be prevented by paying more attention for possible difficult intubation. The positive correlation between age and distance from AEC to RT should be also considered by physicians while endotracheal intubation to prevent unexpected iatrogenic injuries. In addition, new supraglottic airway devices could be designed or existing devices could be developed with the values obtained by measuring critical morphometric properties, thus, folding of EC would be prevented. In conclusion, EC injuries are an iatrogenic injury that occurs during endotracheal intubation and causes severe symptoms in patients. In previous studies, while the thickness, width and height of the EC were evaluated, the distance of AEC to RT, the length of its fixed and free part, the angle between ThC and SE, and the length of larynx were evaluated using MRI in our study. In line with the data obtained from the study, because of the relationship between the distance of AEC to RT and the length of larynx, clinicians could predict the distance of AEC to RT by measuring larynx length via finger calculation.

CONCLUSION

The data obtained as a result of the study reveal the detailed morphometry of EC. In the light of these data, clinicians can predict a possible difficult intubation by evaluating the distance from AEC to RT depending on age and LL during endotracheal intubation. In addition, cervical MR images in which the EC is seen can also be examined before endotracheal tube application, and injury to the EC during intubation can be prevented. Although rare, EC injuries can be prevented. It may be useful to carry out multidisciplinary studies related to the subject in order to contribute to the literature.

Acknowledgment

This study was completed as a master's thesis in Balıkesir University, Faculty of Medicine, Department of Anatomy in 2021.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

Plan, design: ED, AV, BYK; **Material, methods and data collection:** ED, AV; **Data analysis and comments:** ED, AV, EÖ, İK; **Writing and corrections:** ED, AV.

REFERENCES

Ajmani, M. L. (1990). A metrical study of the laryngeal skeleton in adult Nigerians. *Journal of Anatomy*, *171*, 187-191.

Baba, A., Okuyama, Y., Yamauchi, H., Ogino, N., Dorgu, M., Kobashi, Y. et al. (2019). Evaluation of normal epiglottis on computed tomography with special attention to thickness. *The Bulletin of Tokyo Dental College*, *60*(1), 11-16. https://doi.org/10.2209/tdcpublication.2017-0046.

Catalfumo, F. J., Golz, A., Westerman, S. T., Gilbert, L. M., Joachims, H. Z., Goldenberg, D. (1998). The epiglottis and obstructive sleep apnoea syndrome. *The Journal of Laryngology and Otology*, *112*(10), 940-943. https://doi.org/10.1017/s0022211500142136.

Delakorda, M. & Ovşenik, N. (2019). Epiglottis shape as a predictor of obstruction level in patients with sleep apnea. *Sleep & Breathing*, *23*(1), 311-317. https://doi.org/10.1007/s11325-018-1763-y.

Gazayerli, M., Bleibel, W., Elhorr, A., Maxwell, D., & Seifeldin, R. (2006). A correlation between the shape of the epiglottis and obstructive sleep apnea. *Surgical Endoscopy*, *20*(5), 836-837. https://doi.org/10.1007/s00464-005-0641-4.

Hatzakorzian, R., Shan, W. L. P., & Backman, S. B. (2006). Epiglottic hematoma: a rare occurrence after tracheal intubation. *Canadian Journal of Anaesthesia*, *53*(5), 526-527. https://doi.org/10.1007/BF03022630.

Hayran, M., & Hayran, M. Sağlık araştırmaları için temel istatistik. Ankara: Omega Araştırma Organizasyon Eğitim Danışmanlık Ltd. Şirketi, 2011.

Joshi, M. M., Joshi, S. S., & Joshi, S. D. (2011). The morphological study of adult human larynx in a Western Indian population. *Journal of Laryngology and Voice*, *1*(2), 50-54. https://doi.org/10.4103/2230-9748.85062.

Li, S., Wu, D., Jie, Q., Bao'nun, J., & Shi, H. J. (2014). Lingua–epiglottis position predicts glossopharyngeal obstruction in patients with obstructive sleep apnea hypopnea syndrome. *European Archives of Oto-Rhino-Laryngology*, *271*(10), 2737-2743. https://doi.org/10.1007/s00405-014-3033-3.

Lin, T. S., Chen, C. H., & Yang, M. W. (2004). Folding of the epiglottis - an unusual complication to be recognized after laryngoscopic endotracheal intubation. *Journal of Clinical Anesthesia*, *16*(6), 469-471. https://doi.org/10.1016/j.jclinane.2003.11.006.

Mohammadi, S. S., Tavakkoli, A. B., & Maraşi, M. (2020). Correlation between ultrasound measured distance from skin to epiglottis and epiglottis to mid-vocal cord with Cormack-Lehane classification for predicting difficult intubation. *Archives of Anesthesiology and Critical Care*, *6*(1), 23-26. https://doi.org/10.18502/aacc.v6i1.2045.

Poornima, G. C., & Dakshayini, K. R. (2017). A study of morphometry of adult human larynx and its importance in clinical applications. *International Journal of Anatomy and Research*, *5*(2.1), 3713-3717. https://doi.org/10.16965/IJAR.2017.155.

Sprinzl, G. M., Eckel, H. E., Sitte, C., Pototschnig, C., & Koebke, J. (1999). Morphometric measurements of the cartilaginous larynx: An anatomic correlate of laryngeal surgery. *Head and Neck, 21*(8), 743-750.

Torre, C., Camacho, M., Liu, S. Y. C., Huon, L. K., & Capasso, R. (2016). Epiglottis collapse in adult obstructive sleep apnea: A systematic review. *The Laryngoscope, 126*(2), 515-523. https://doi.org/10.1002/lary.25589.

Van Zundert, A. A. J., & Wyssusek, K. H. (2018). Epiglottis folding double with supraglottic airway devices. *British Journal of Anaesthesia, 120*(4), 884-885. https://doi.org/10.1016/j.bja.2018.01.015.