



Morphometric study of cricoid cartilages in Western India

Mohini Joshi ¹, Sharda Joshi ², Subhash Joshi ³

1. Assistant Professor, Department of Anatomy, Rural Medical College, Pravara Institute of Medical Science, Loni, Maharashtra, India

2. Professor and Head, Department of Anatomy, Arbindo Institute of Medical Sciences, Indore, MP, India

3. Dean, Arbindo Institute of Medical Sciences, Indore, MP, India

RESEARCH

Please cite this paper as: Joshi MM, Joshi SS, Joshi SD
Morphometric study of cricoid cartilages in Western India
AMJ 2011, 4, 10, 542-547
<http://doi.org/10.21767/AMJ.2011.816>

Corresponding Author:

Name Dr. Mohini Joshi
Address Assistant Professor,
Department of Anatomy,
Rural Medical College,
Pravara Institute of Medical Science, Loni,
Maharashtra, India
Email:atharvamohini@gmail.com

Abstract

Background

It is important to determine the size and proportion of the larynx as such information is useful in procedures such as intubation, endoscopy and surgical manipulations. Recent interest in the cases of subglottic stenosis and post-intubational stenosis of the lower respiratory tract has led to renewed interest in ascertaining the measurements of the various laryngeal cartilages. The aim of the present study was to collect morphometric data of cricoid cartilage from a regional population.

Method

Fifty laryngeal preparations from adult cadavers of Western India were assessed. Sections were prepared via dissection and the removed cricoid cartilages then measured and weighed.

Results

The mean antero-posterior diameter (19.29 ± 2.47) of the cricoid cartilage was greater than the average transverse diameter (18.33 ± 2.26). The height of arch of cricoid cartilage was 6.54 ± 1.23 mm and height of lamina was 21.45 ± 1.97 mm. Mean weight of cricoid cartilage was

4.53 ± 1.27 grams. The shape of the cricoid cartilage was ovoid in 46% of cases, oval in 38%, pear shaped in 12% and narrow-oblong in 4% of cases.

Conclusion

Inter-subject variability in the dimensions of cricoid cartilages was observed. The large difference in almost all sizes and shapes of the cricoid cartilage makes it difficult to standardise the rigid stents used in these organs. Endotracheal tubes of the appropriate size should therefore be based on the measurements of individual patients. Clinicians should therefore be aware of morphological variations as they are of fundamental clinical importance.

Key Words

Cricoid cartilage, larynx, morphometry

What this study adds:

1. There is a paucity of literature relating to measurements of the cricoid cartilages amongst the Indian population, and none providing details on the population from Western India. This study provides a comprehensive and detailed description of the various dimensions of the cricoid cartilage.
 2. Knowledge of such measurements is of fundamental importance for clinical use and its applicability in endotracheal intubation and in preventing unnecessary injuries to the larynx.
 3. The large difference in almost all sizes and shapes of the cricoid cartilage makes it difficult to standardise the rigid stents used in these organs. Appropriately sized endotracheal tubes should therefore be used for intubation based on the measurements of the presenting individual.
-

Background

The larynx is a sphincteric device and an organ of phonation. It extends from the tongue to the trachea, has evolved and developed a complex mechanism of skeletal structures and neuro-muscular control which allows it to modify the expiratory stream. This allows the production of highly complex patterns of sound with varying loudness,



frequency and duration. Until puberty, the male and female larynges are similar in size but, afterwards, the male larynx enlarges considerably in comparison to the female: all the cartilages increase in size and the thyroid cartilage projects anteriorly in the midline of the neck, while its sagittal diameter nearly doubles during this process.¹ From embryologic, anatomic, physiologic and surgical standpoints, the larynx is one of the most complex organs of the human body.²

Morphometrical evaluation of the larynx has always been interesting for both morphologists and physicians.³ The increasing application of sophisticated electrophysiological and radiological methods for the diagnosis and treatment of laryngeal disorders requires an extensive knowledge of the size and proportions of the human larynx and its cartilaginous components.⁴ A thorough understanding of the anatomy and the knowledge of variations in the laryngeal cartilages is therefore important, especially while interpreting head and neck radiographs of patients who exhibit anatomical or functional deviations. Recent interest in the cases of subglottic stenosis and post-intubational stenosis of the lower respiratory tract have led to renewed interest measurements of the various cartilages of the larynx.⁵ Morphometric data of the larynx may be useful in otorhinolaryngology procedures such as conicotomy, total laryngectomy, partial laryngectomies, laryngeal microsurgery, and evaluation of results of diagnostic techniques. It may also help in selecting the right dimensions of operational tools,³ as such measurements would be useful in procedures such as endoscopy, surgical manipulations and in endotracheal intubation to prevent unnecessary injuries to the larynx.⁶

Examination of the literature reveals there is a paucity of information on this important subject for the Indian population, and none from the western region of the country. Therefore, the aim of this study was to collect exact and reliable morphometric data of cricoid cartilages in a regional population from Western India.

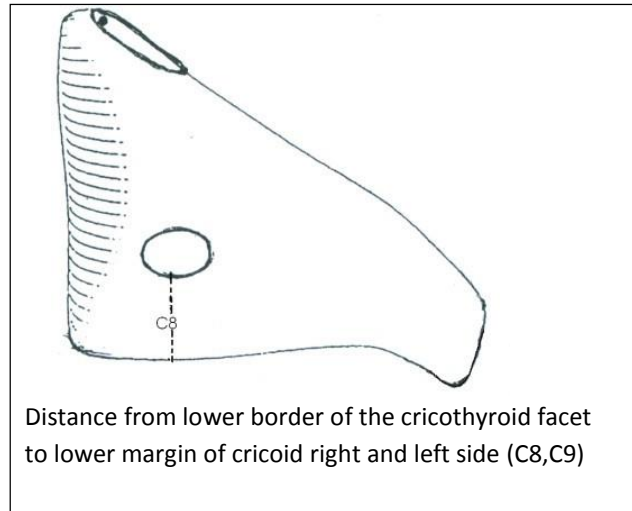
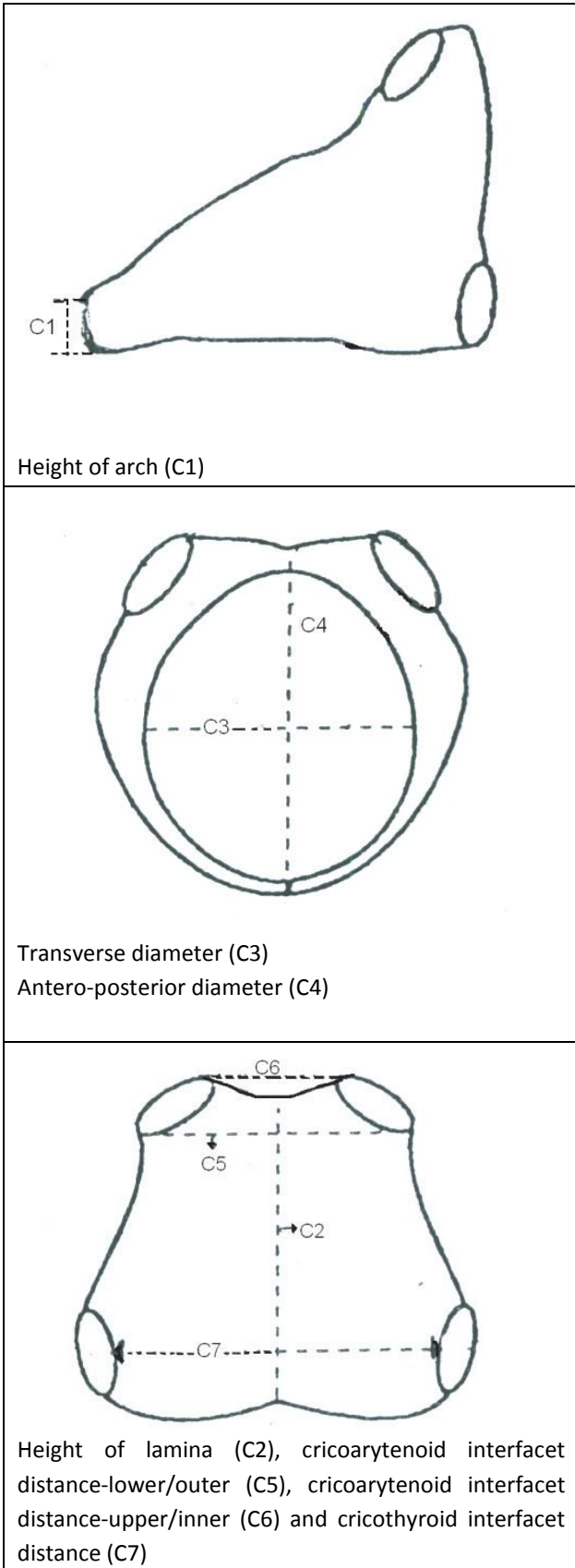
Method

The study was approved by the Ethical and Research Committee of the Rural Medical College, Pravara Institute of Medical Sciences (Deemed University), Loni. The sample consisted of 50 laryngeal preparations from adult cadavers (age: 59–78, mean 67.5). Any cadaver with the possibility of laryngeal damage as a result of disease, diagnostic procedures or surgical manipulation was excluded from the study.

A sagittal section of the head and neck region was removed from the cadaver. Along with the tongue, the specimen of the larynx was removed by cutting the muscles of the soft palate, the muscles of the posterior pharyngeal wall, and the surrounding fascia. The larynx was separated from the tongue from the level of hyoid bone to the third tracheal ring. Dissection was performed using standard dissecting instruments under magnification (hand lens and dissecting microscope [OPMI 99; Zeiss, New York]). Removed cartilages were cleaned of all the extrinsic muscles and then separated from each other. All the soft tissue and mucous membrane attached to the cartilages was removed and the cartilages immersed and preserved in 5% formalin. Cricoid and thyroid cartilages were dried with blotting paper then weighed on a single pan electronic balance (Shimadzu BL series 2204; Japan, sensitive to 0.01 gm). Various measurements were taken from the cricoid cartilages with a handheld Digital Vernier Caliper (Mitutoyo, Japan) to the nearest 0.01 mm (Figures 1–2):

- Height of arch (C1): Vertical distance between upper and lower borders of the arch in the middle.
- Height of lamina (C2): Vertical distance between upper and lower borders of the lamina in the middle.
- Transverse diameter (C3): Maximum distance between the two sides of the arch in the middle.
- Antero-posterior diameter. (C4): Antero-posterior transverse distance between the middle of inner surfaces of the arch and the lamina.
- Cricoarytenoid interfacet distance-lower/outer (C5): Transverse distance between the lowest points of the two cricoarytenoid facet.
- Cricoarytenoid interfacet distance-upper/inner (C6): Transverse distance between the highest points of the two cricoarytenoid facet.
- Cricothyroid interfacet distance (C7): Transverse distance between the two cricothyroid facets.
- Distance from lower border of the cricothyroid facet to lower margin of cricoid right side (C8).
- Distance from lower border of the cricothyroid facet to lower margin of cricoid (left side) (C9).
- Cricoid weight.

Figure 1: Dimensions of cricoid cartilage



Shapes of the cricoid cartilage were noted and were classified into four groups: ovoid, oval, pear, and narrow-oblong.

Data was entered into Microsoft Excel (Microsoft Corporation, Silicon Valley, Ca.) and analysed using StatistiXL version 1.8 software (statistiXL, Australia). For each of the parameters, the mean, standard deviation (S.D.) and range (minimum value -maximum value) was calculated. Data was analysed in the form of percentage and proportions.



Figure 2: Photograph indicating how measurement of cricoid cartilage lamina was performed

Results

Table 1: Cricoid cartilage dimensions

Sr.No	Parameter (1-4 mm,5- gms)	Mean (mm)	S.D. (mm)	Range(mm)
1	Height of arch (C1)	6.54	1.23	3.82-10.67
2	Height. of lamina (C2)	21.45	1.97	16.68-24.93
3	Transverse diameter (C3)	18.33	2.26	13.88-24.05
4	Antero-posterior diameter (C4)	19.29	2.47	13.68-24.56
5	Cricoid weight-grams	4.53	1.27	1.97-7.9

Table 2: Cricoid cartilage interfacet distance

Sr.No	Parameter	Mean (mm)	S.D. (mm)	Range (mm)
1	Cricoarytenoid interfacet distance-lower/outer (C5)	19.47	2.41	13.24-23.14
2	Cricoarytenoid interfacet distance-upper/inner (C6)	12.07	2.35	7.52-20.74
3	Cricothyroid interfacet distance (C7)	22.79	3.17	15.99-32.27
4	Distance of cricothyroid facet to lower margin of cricoid -Right side (C8)	6.41	1.69	1.74-9.71
5	Distance of cricothyroid facet to lower margin of cricoid- Left side (C9)	6.45	1.71	1.95-9.69

Dimensions, weight of cricoid cartilage and interfacet distances are given in Tables 1 and 2. It was observed that the mean antero-posterior diameter of the cricoid cartilage was greater than the average transverse diameter. The mean cricoarytenoid interfacet distance-outer and the mean cricoarytenoid interfacet distance-inner were 19.47 ± 2.41 and 12.07 ± 2.35 mm respectively. Left-right symmetry was observed in relation to the distance of the cricothyroid facet to the lower margin of cricoid on the right side (6.41 ± 1.69) and the left side (6.45 ± 1.71). The mean weight of the cricoid cartilages was 4.53 ± 1.27 grams.

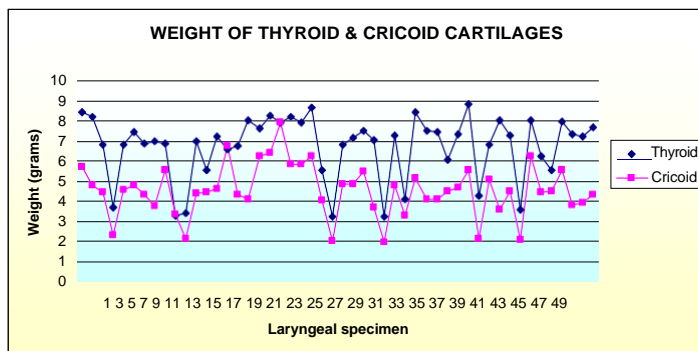


Figure 3: Weight cricoid and thyroid cartilages

The mean weight of the thyroid cartilage was 6.70 ± 1.55 grams showing that in every specimen the thyroid cartilage was heavier than the cricoid cartilage (Figure 3).

Table 3: Shapes of the cricoid cartilage

Sr. No.	Shape	No.	%
1	Ovoid	23	46
2	Oval	19	38
3	Pear shaped	6	12
4	Narrow oblong	2	04

The shape of the cricoid cartilage (Figure 4) was found to be ovoid in 46% of cases, oval in 38% of cases, pear shaped in 12% of cases and narrow oblong in 4% of cases (Table 3).



Figure 4: Photograph shows the typical signet ring shape of the cricoid cartilage

Discussion

The morphological aspects of the cricoid cartilages have been studied in the Western population.^{3,4,8} However, a great need still exists for detailed information on the



physical parameters of the cricoid cartilages and their degree of variability. In the present study inter-subject variability in the dimensions was observed. The findings of the present work are in agreement with those described by other workers who conducted similar studies.^{5,7-9} Individual variations, though not reported, can be observed from the published data of the metrical studies of laryngeal cartilages in Nigerians and Indians.^{5,7}

Dimensions, weight of cricoid cartilage and interfacet distances (Figure 1) are given in Tables 1 and 2. In the present study the height of arch of cricoid cartilage (C1) was 6.54±1.23 mm. Similarly, in a study carried out by Harjeet and Jit (2002)¹⁰ in north-west Indians the height of arch of cricoid cartilage was 6.13±1.02 mm, while the study carried out in Haryana (India) indicated the height of arch of cricoid cartilage was 6.00± 0.08 mm.⁹ Ajmani (1990)⁵ observed that in Nigerians the anterior height of cricoid arch was 8.35± 4.30mm, and Zelinski et al. (2001)³ observed that the height of arch of cricoid cartilage was 8.82±1.4 mm in Poland. In the study of Tayama et al. (2001)¹¹ the anterior height of cricoid arch was 7.05±1.02mm.

Table 4: Comparison of cricoid cartilage dimensions

Parameter	Present study	Harjeet North-west Indian	Ajmani Nigerians	Eckel et al Germans	Jain et al North Indian	Zelinski et al Poland
Height of arch (C1)	6.54±1.23	6.13±1.02	8.35±4.30	6.90±1.35	6.00±0.08	8.82±1.4
Height of lamina (C2)	21.45±1.97	18.59±1.68	26.50±6.30	24.60±1.84	22.00±0.19	27.95±3.17
Transverse diameter (C3)	18.33±2.26	16.53±1.04	29.84±6.10	26.40±2.40	17.20±0.36	-
Antero-posterior diameter (C4)	19.29±2.47	20.22±1.65	28.82±4.07	30.90±3.06	19.50±0.25	-

While there is agreement between our values and that reported by other workers on the Indian subjects, there is great disparity with that of the Nigerian and Polish population. This may be accounted for due to racial differences. It can be inferred from Table 4 that both the height of arch of cricoid cartilage (C1) and height of lamina of cricoid cartilage (C2) in the regional population are smaller than those in Nigerians, German and Polish populations. It is possible that this discrepancy could be explained in part by differences in ethnicity.

In the present study the average antero-posterior diameter (Table 1) of the cricoid cartilage was greater than the average transverse diameter. This is similar to the observations of Harjeet and Jit (2002)¹⁰, Eckel et al. (1994)¹², Jotz et al. (2007)⁶ and Jain et al. (2008)⁹ who reported that the mean antero-posterior diameter of the cricoid cartilage was greater than an average transverse diameter in adults. Lakhal et al. (2007)¹³ compared the transverse diameter of the cricoid lumen assessed by ultrasonography and magnetic resonance imaging (MRI). MRI measurements indicated that the cricoid lumen transverse diameter (15±2 mm) was smaller than that of the antero-posterior (19±3 mm; P < 0.05). However, contrary to these findings Ajmani (1990)⁵ found the mean transverse diameter to be greater than the mean antero-posterior diameter.

The weight of cricoid cartilage was 4.53±1.27 grams (Table 1). Harjeet and Jit (2002)¹⁰ reported a maximum weight of the cricoid cartilage as 4.72 grams; Jain et al. (2008)⁹ reported a mean weight of 4.27±1.31 grams; Maue and Dickson (1971)⁸ observed a mean weight of 5.80 grams. In conclusion, the findings of the present work are in agreement with the Indian studies, but the values reported by Maue and Dickson (1971)⁸ were higher for the North Americans.

Cricothyroid interfacet distance-lower/outer (C5) was 19.47±2.41mm and cricothyroid interfacet distance-upper/inner (C6) was 12.07±2.35 mm (Table 2). Findings of the present work are close to that observed by Harjeet and Jit (2002).¹⁰ In the present study Cricothyroid interfacet distance (C7) was 22.79±3.17mm (Table II). Harjeet and Jit (2002)¹⁰ reported that the external transverse distance between two cricothyroid facets was 27.81±4.43 mm. The higher value in this study could be due to the fact that they have measured cricothyroid interfacet distance from outer (lateral) borders of cricothyroid facets whereas in the present study it was measured from inner (medial) borders of the cricothyroid facets. In the present study the distance of the cricothyroid facet to the lower margin of cricoid; the right side (C8) was 6.41±1.69 mm and 6.45±1.71mm on the left (C9) (Table 2). As the cricoid cartilage is narrow in front and broader in back, the shape resembles a signet ring (Figure 4). Variations in the shapes of the cricoid cartilage were observed. In 46% of specimens the larynx cricoid cartilage was found to be ovoid in shape, with a greater anterior-posterior diameter (Table 3). No comparable data was found to be available in the literature.

Conclusion

This study provides a comprehensive and detailed description of various morphological dimensions of the



cricoid cartilage from a local population in Western India. Comparison of these results to other studies reveals that the morphology of the cricoid cartilage differs between populations, and it is possible that this could be due to differences in body shape and race. The large difference in almost all sizes and shapes of the cricoid cartilage makes it difficult to standardise the rigid stents used in these organs. Appropriately sized endotracheal tubes should therefore be used for intubation. Knowledge of such measurements and variations is of fundamental importance for clinical practice in order to prevent unnecessary injury to the larynx.

References

1. Standring S. *Gray's Anatomy: The anatomical basis of clinical practice*, 40th ed. London: Elsevier Churchill Livingstone, 2008: 577-593
2. Skandalakis J. *Skandalakis surgical anatomy. The embryologic and anatomic basis of modern surgery*. 1st ed. vol. 1. Greece: Pashalidis Medical Publications Ltd.; 2004. p. 234-62.
3. Zielinski R. Morphometrical study on senile larynx. *Folia Morphol* 2001; 60(2):73-78.
4. Sprinzl G. Morphometric measurements of the cartilaginous larynx: An anatomic correlate of laryngeal surgery. *Head Neck* 1999; 21:743-750.
5. Ajmani M. A metrical study of laryngeal skeleton in adult Nigerians. *J. Anat* 1990; 171:187-191.
6. Jotz P. The asymmetry index of the cricoid cartilage and the external angle of thyroid cartilage. A sex related study. *Eur J. Anat* 2007; 11(1):1-7.
7. Ajmani M, Jain S, Saxena S. A metrical study of laryngeal cartilages and their ossification. *Anatomischer Anzeiger* 1980; 148:42-48.
8. Maue W, Dickson D. Cartilages and ligaments of the adult human larynx. *Arch Otolaryngology* 1971, 94:432-439.
9. Jain M, Dhall U. Morphometry of the thyroid and cricoid cartilages in adults. *J Anatomical Society of India* 2008; 57(2):119-123.
10. Harjeet, Jit I, Sahani D. Dimensions and weight of the cricoid cartilage in northwest Indians. *Indian J Med Res* 2002; 116:207-216.
11. Tayama N. Geometric characterization of the laryngeal cartilage framework for the purpose of biomechanical modeling. *Annals of Otol, Rhinol. Laryngol* 2001; 110(11):1154-1161.
12. Eckel H, Sittel C, Zorowka P, Jerke A. Dimensions of the laryngeal framework in adults. *Surg Radiol Anat* 1994; 16:31-36.
13. Lakhali K, Xavier D, Jean-Philippe C, Xavier S. The feasibility of ultrasound to assess subglottic diameter. *Anesth Analg* 2007; 104:611-614.

PEER REVIEW

Not commissioned. Externally peer reviewed

CONFLICTS OF INTEREST

No

FUNDING

None

ETHICS COMMITTEE APPROVAL

Ethical approval for this study was granted by the Ethical and Research Committee of Rural Medical College, Pravara Institute of Medical Sciences (Deemed University), Loni.