MATERIAL AND METHODS
The material used in this study consisted 295 larynges of various ages obtained from the medico-legal cases on whom post-mortem had been performed by Head of the Department of Anatomy and Forensic Medicine, P.G.I., Chandigarh.

Numbers of larynges which were examined and their age groups:

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult males</td>
<td>100</td>
</tr>
<tr>
<td>Adult females</td>
<td>50</td>
</tr>
<tr>
<td>Children</td>
<td>45</td>
</tr>
<tr>
<td>Neonates</td>
<td>25</td>
</tr>
<tr>
<td>Fetuses</td>
<td>75</td>
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</tbody>
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Normally in western countries 300 mm CR length is the dividing line for demarcating newborns from fetuses but in India the weight of the newborns is less than in western countries so that fetuses between 250 mm to 299 mm CR length could be put in one category or the other. Initially these 25 specimens measuring in size from 250-299 mm were considered as newborns but later on it was decided that they should be included in the term 'fetuses' as they were still borns and
appeared premature. The author's work is based on C.R. lengths of the fetuses and neonates, it would not make any difference if the premature neonates are included in the category of fetuses. In fact it appears to be more scientific. Hence the number of fetuses got increased to 75 and number of newborns reduced to 25.

At the time of postmortem examination name, address, sex, age, height, weight, neck-length from supra-ternal notch to the upper border of the hyoid bone (there is no other fixed point for measuring the neck length) of cadavers were recorded. All the subjects belonged to Chandigarh zone which included Punjab, Haryana, Himachal and U.T. Chandigarh. The usual procedure of separating the organs including the neck structures was followed at autopsy. The midline incision on the abdomen and thorax was extended to the neck to reach the symphysis menti. The skin and superficial fascia were reflected laterally to expose the root of the tongue, oesophagus, larynx, thyroid gland and the trachea. The soft tissues were dissected lateral to these structures and tongue separated at its postero-lateral attachment (palatoglossal arch). The tongue alongwith the structures in the neck mentioned above were pulled down caudally and removed along with the thoracic and abdominal organs in one piece. After the thoracic and abdominal organs had been examined and dealt with, ribbon muscles and cervical part of the oesophagus were removed. A transverse incision was made just below the inferior poles of the thyroid gland and the tongue was also separated. The thyroid gland was then
removed and the entire larynx from the epiglottis to the lower border of cricoid cartilage isolated. Measurements of the larynx taken were:

1. Length of the larynx from the highest point of the epiglottis to the inferior margin of the cricoid cartilage in the mid-line. When measuring the length, the epiglottis was kept vertically straight.

2. Outer transverse diameter. It is the maximum side to side distance at the level of superior thyroid tubercles.

3. Maximum outer antero-posterior diameter.

4. Distance between the thyroid and cricoid cartilage anteriorly.

The larynx was then preserved in 5% formalin. After 3-4 days, the laryngeal cartilages were separated and cleaned of all soft tissues. As the separated cartilages were likely to get shrunken if exposed to air, they were kept preserved in 5% formalin in glass jars suitably labelled. Earlier the specimens were preserved in normal saline as it was thought that the cartilages may shrink further if kept in formalin. After experimenting with several specimens it was found that no shrinkage took place after the cartilage had been fixed for 3-4 days in 5% formalin. They were not kept in normal saline.

The various laryngeal cartilages were then measured with the help of a Vernier caliper (Mitutoyo, Japan) which gave an accurate measurement to the tune of 0.02 mm. The cartilages were weighed after they had been dried with blotting paper. They were not put in hot air oven because when the cartilages were kept even for few minutes, they got distorted. Exposure of cartilages to atmosphere for a couple of hours also makes them
crooked and unshapely.

**THYROID CARTILAGE (Fig.1)**

1. **Anterior height of lamina (interlaminar height)**
   i.e. the distance between the lowest point of the superior thyroid notch and the middle point (vertically below the notch) of the inferior border. (Fig.1A)

2. **Transverse distance between the tips of superior cornua (Fig.1A)**
   a. Inbetween external surfaces
   b. Inbetween internal surfaces
   c. Inbetween the highest points of the tips

3. **Transverse distance between the tips of inferior cornua (Fig.1A)**
   a. Inbetween external surfaces
   b. Inbetween internal surfaces
   c. Inbetween the lowest points of the tips

4. **Transverse distance between the medial surfaces of the bases of the superior cornua (Fig.1D)**

5. **Transverse distance between the medial surfaces of the bases of the inferior cornua (Fig.1D)**

6. **Vertical distance between the tips of the superior and inferior cornua on either side (Fig.1C)**

7. **Curvilinear length** from the highest point of tip of the superior cornu to the lowest point of the tip of inferior cornu along the posterior border of the lamina on either side as measured by a piece of thread. (Fig.1B)

8. **Depth of the curve of the posterior border of thyroid lamina**
   It is the transverse distance measured between the straight lines drawn from the outer margins of the bases of the superior and inferior cornua and maximum concavity of the posterior border of thyroid lamina of both sides. (Fig.1C)
9. **Maximum height of right and left lamina (Fig.1C)**

As there were no fixed points for measuring the height of the lamina, it was decided that height could be measured at two places

a. **Vertical distance between the highest point of the superior border of lamina and inferior border of the same lamina.** Highest point of superior border is located at the commencement of superior thyroid notch.

b. **Vertical distance between inferior most point of the inferior border of lamina and superior border of the same lamina.** In all instances the inferior most point of the tubercle is the lowest point on the inferior border.

10. **Upper breadth of the right and left lamina (Fig.1A)**

It is the transverse distance measured between the lowest middle point of superior thyroid notch and the posterior border of the lamina on either side (right and left).

11. **Lower breadth of the right and left lamina (Fig.1A)**

It is the transverse distance between the middle of the inferior border (vertically below the superior thyroid notch) and the posterior borders of the lamina on either side (right and left).

12. **Distance between the bases of the superior and inferior cornua on either side (Fig.1B)**

This is the distance between the medial side of the base of the superior cornu and the medial side of the base of the inferior cornu. Base is the point where curved part of the superior or inferior border of thyroid lamina begins.
13. **Length of superior right and left cornua (Fig.1C)**
   i.e. the distance between the upper most point of the tip of superior cornu and a horizontal line drawn at its base. Curvatures of the cornua are ignored.

14. **Length of inferior right and left cornua (Fig.1C)**
   i.e. the distance between the lower most point of the tip of inferior cornu and a horizontal line drawn at its base. Curvatures of the cornua are ignored.

15. **Height of superior thyroid notch (Fig.1D)**
The distance between the lowest middle point of thyroid notch to the transverse line drawn at the highest points of the superior borders of the laminae. As the superior border is curved at the sides of the notch it is not possible to have any fixed points except to take the highest points of the upper border. A flat metal strip is placed on the highest points of respective lamina and depth of the notch measured from its middle upto the strip.

16. **Width of superior thyroid notch (Fig.1D)**
The horizontal distance between the points where the curves of the superior thyroid notch meet the superior border of the two laminae. This measurement is not expected to be accurate because of variability in the curvature at the upper part of the notch on the two sides.

17. **Thyroid angle**
The angle formed by the anterior border at the junction of two laminae, slopes downwards and backwards from the superior thyroid notch and as such the upper angle just below the notch and the lower angle just above the mid-point of the inferior border are not equal, hence the two measurements are necessary.
Superior thyroid angle

Thyroid angle is the posterior angle formed by the two laminae as they meet at anterior border just below the superior thyroid notch. It is measured by a flexible thin strip.

A thin flexible strip made of tin is applied against the outer surface of the one lamina just below the superior thyroid notch and bent at the anterior border and then applied against the front of outer surface of the other lamina. The V-shaped angle formed by the strip corresponds to the angle of the lamina. As the projection at the anterior border of thyroid cartilage is rounded, the bend between the two parts of strip will also be rounded. It is placed on a piece of paper and lines drawn against the two limbs of strip and projected forward towards the angle to meet at a point anterior to the bend of strip. Angle found by the two lines is measured with a protracter.

Inferior thyroid angle

It is the angle formed by the two laminae anteriorly just above the mid-point of the inferior border. For measuring the inferior angle the strip is applied against the anterior border just above the inferior borders of the two laminae and angle measured in the same manner as the superior angle.

18. Weight was taken with a single pan electric balance after the cartilage had been dried as described earlier.

CRICOID CARTILAGE (Fig. 2)

1. Anterior height of arch (Fig. 2A)
The distance between the upper and lower borders of the anterior arch in the middle.
2. **Height of lamina (Fig. 2B)**
   The perpendicular distance between the upper and lower borders of the lamina in the middle.

3. **Transverse diameter of the cartilage**
   a. External distance - It is the transverse distance between the two crico-thyroid facets which are the lateral most points (Fig. 2B).
   b. Internal distance - It is the maximum distance between the two sides of the arch. The points for measuring this distance do not correspond to the cricothyroid facets on the outer side (Fig. 2C).

4. **Antero-posterior diameter of the cricoid cartilage**
   a. External distance - It is the greatest distance between the outer surfaces of the lamina and arch in the middle line (Fig. 2A).
   b. Internal distance - It is the distance between inner surfaces of anterior arch and lamina in the middle.

5. **Outer circumference of the cartilage** as measured transversely by a thread at the level of middle (midway between upper and lower borders) of arch anteriorly.

6. **Maximum thickness of arch** in the middle anteriorly.

7. **Maximum thickness of lamina** in the middle line.

8. **Inter-facets distance (Fig. 2C)**
   a. Transverse distance between the highest points of the two crico-arytenoid facets.
   b. Transverse distance between the lowest points of the two crico-arytenoid facets.

9. **Length of the axis of crico-arytenoid facet (Fig. 2C)**
   It is the length of the axis which runs from above, downwards, forwards and laterally on the facet.
10. **Breadth of the crico-arytenoid facet** at right angle to its long axis in the middle of the facet. (Fig. 2C)

11. **Distance from the centre of each crico-arytenoid facet to the superior border of the cricoid arch anteriorly in the middle line.**

12. **Angle** between the long axes of the two crico-arytenoid facets. The axes of the two facets are projected backwards where they meet at an acute angle. (Fig. 2C)

13. **Weight** was taken with a single pan electric balance after the cartilage had been "dried" as described earlier.

**ARYTENOID CARTILAGE**

1. **Distance from apex to muscular process** (Fig. 3A)

2. **Distance from apex to vocal process** (Fig. 3B)

3. **Distance from muscular process to vocal process** (Fig. 3B)

4. **Size of the crico-arytenoid facet**
   
a. **Antero-posterior diameter** (This diameter is actually between antero-medial and postero-lateral points).
   
b. **Above-downward diameter**. It is at right angle to the axis 'a' diameter. It runs from the upper to lower margin of the crico-arytenoid facet.

5. **Length of the vocal process**
   It is the distance between the anterior border of the crico-arytenoid facet and tip of the vocal process.

6. **Height of cartilage**
   The vertical height was measured posteriorly from apex to base without considering the curvature of the posterior surface or the apex.
7. Weight was taken with a single pan electric balance after the cartilage had been dried as described before.

**EPIGLOTTIS**

1. **Maximum length of the cartilage** is the distance measured from the upper border to the lower end of the root of the epiglottis in the middle. (Fig. 4)

2. **Maximum breadth** is the maximum distance measured between the lateral borders. (Fig. 4)

3. **Maximum thickness** at the tubercle

4. Weight was taken with a single pan electric balance after the cartilage had been dried as described earlier.

**Study of joints and ligaments**

In 25 specimens the cartilages were not separated. They were left in situ articulating with one another. Ligaments of the crico-thyroid and crico-arytenoid joints were exposed and studied.

All measurements were statistically analysed on ESPL computer provided by ICMR to the Department of Community Medicine, P.G.I.

**Procedure undertaken to study calcification of the laryngeal cartilages**

**Thyroid cartilage**

1. After the thyroid cartilage had been fixed in formalin for a period of one week, all soft tissues were removed by scraping. The cartilage was examined against a strong light and calcified area delineated. The procedure was found unsatisfactory and therefore given up.
2. The entire cartilage was x-rayed on ordinary films. Antero-posterior and lateral views were obtained separately for each lamina by putting a lead sheet in between. The delineation of calcified area was again found to be unsatisfactory and therefore the procedure was given up.

3. The thyroid cartilage was cut into its two laminae at their anterior border exactly in the middle line. Each lamina was then x-rayed on ordinary film and calcified areas noted. This procedure was also found to be unsatisfactory.

4. The thyroid cartilage was cut vertically in the middle into its two laminae. Each lamina was x-rayed in an antero-posterior view on a dental "occlusal" film of the size 5.6 x 7.5 cm. The procedure was found to be extremely satisfactory and was, therefore, adopted. After the procedure, the cartilages were preserved in 5% formalin.

Cricoid cartilage

Attempts were made to get the calcified areas demarcated in a postero-anterior and lateral views of the cartilage on dental occlusal films. The procedure was found to be unsatisfactory as there was considerable degree of overlapping. The cartilage was then divided vertically on both sides at the junction of the arch and the lamina, the arch was further divided into two halves anteriorly. The cartilage was now in 3 pieces which were x-rayed on a dental film and was adopted in 20 male and 20 female specimens varying in ages from 16 years to 75-80 years.

Arytenoid cartilage

The arytenoid cartilage was x-rayed on dental "occlusal" film in postero-medial views so that the posterior and medial surfaces, the two process and apex were well seen.
CRICOID CARTILAGE

A  SIDE VIEW OF LAMINA

B  POSTERIOR VIEW OF LAMINA

C  SUPERIOR VIEW

FIG. 2
ARYTENOID CARTILAGE  
(LATERAL VIEW)

A     B

A. LEFT ARYTENOID
B. RIGHT ARYTENOID

FIG. 3
FIG. 4