The Shape of the Human Adult Trachea

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The adult trachea has been described as triangular, elliptical, C-shaped, and non-circular in cross-section. Tracheal shape has been suggested as a possible reason for trauma occurring as a result of intubation in reference to Morquio’s disease, where malformation of the tracheal cartilage is found. The adult trachea is not circular, but the cuff of a freely inflated endotracheal tube is circular in cross-section. To seal the airway this cuff must either conform to or deform the trachea. A high-compliance cuff should conform, but damage to the trachea has been reported. There appears to be no single etiologic factor in the development of tracheal damage, although many predisposing factors have been reported. The cross-sectional shape of the trachea would seem to be another important determinant of damage. For this reason, cross-sectional tracheal shapes were studied.

**METHOD**

One hundred eleven adult tracheas were dissected at autopsy and specimens obtained. Cross sections

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shapes were also seen frequently. These were the D shape (12.6 per cent) and the elliptical (8.2 per cent). The D-shaped trachea had a large membranous portion, the transverse diameter was larger than the anteroposterior diameter, and the cartilage made an acute angle with the membranous portion. The elliptical trachea had a larger transverse than anteroposterior diameter, and the cartilage made an obtuse angle with the membrane.

Rarely, tracheal shapes were circular (1.8 per cent) or triangular (1.8 per cent). The circular trachea was an almost complete ring of cartilage, with a small, practically nonexistent membranous portion. The triangular trachea had approximately equal anteroposterior and transverse diameters, and the cartilage made an acute angle with the membrane.

Of the 111 specimens, 103 were similarly classified by independent observers. Differences in classification were due to the problem of differentiating U, C and elliptical shapes when the anteroposterior and transverse diameters were nearly equal. These eight transitional specimens were classified by mutual agreement between observers.

There was no correlation between patient age, weight, height, sex, or race and any of the tracheal shapes studied. Mean sex was 42.3 years (range 16–69), mean weight 70.9 kg (37.7–138.6) and mean height 170 cm (147–196). Eighty-two patients were male. Sixty-four patients were white, 45 black, and two oriental.

CAT scans at the level of the sternoclavicular joint in 31 patients confirmed the presence of all the above shapes in vivo. The distribution of shapes is shown in table 1. There was no difference between frequencies of CAT scan and anatomic shapes ($\chi^2$ test, $P > 0.05$).

**DISCUSSION**

The specimens showed considerable variation in tracheal cross-sectional shape. The same shapes were confirmed in non-intubated patients by CAT scan.

<table>
<thead>
<tr>
<th>Anatomic Shape</th>
<th>C</th>
<th>U</th>
<th>D</th>
<th>Elliptical</th>
<th>Circular</th>
<th>Triangular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>54</td>
<td>30</td>
<td>14</td>
<td>9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Per cent</td>
<td>48.6</td>
<td>27</td>
<td>12.6</td>
<td>8.2</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>CAT scan</td>
<td>13</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number</td>
<td>42</td>
<td>29</td>
<td>12.9</td>
<td>9.7</td>
<td>3.2</td>
<td>3.2</td>
</tr>
</tbody>
</table>

**Table 1. Incidences of Anatomic and CAT Scan Cross-sectional Tracheal Shapes**

There is no evidence that these shapes are influenced by postmortem changes or formalin-induced shrinkage. However, during ventilation and coughing tracheal shape is known to change. The compliance of the trachea decreases with age, and its length and volume increase with positive pressure in the airway.\(^\text{11}\) Shape may also be influenced by the effect of the supporting tissues around the trachea.

It is important to differentiate between tracheas that have larger anteroposterior than transverse diameters and those that have larger transverse diameters. U-shaped tracheas fall into the former group, D-shaped and elliptical tracheas into the latter.

If anteroposterior and lateral diameters could be identified prior to endotracheal intubation, an anatomically designed cuff might reduce the damage inflicted during prolonged intubation. We are presently studying anteroposterior and lateral air tracheograms as a noninvasive technique of tracheal measurement. Although CAT scanning is the ideal method of identification of tracheal shape, it is not presently practical in most situations.

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**REFERENCES**


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Spontaneous Dislocation of Endotracheal Tubes

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The concern about laryngeal and tracheal injury from prolonged endotracheal intubation has led to development of softer tubes with large-diameter/low-pressure cuffs. While these innovations have decreased the incidence of pressure necrosis of the tracheal mucosa, they have also created new problems. For instance, nasogastric tubes and other esophageal devices may accidentally enter the trachea, unimpeded by the soft cuff of the tracheal tube.1

During 1975, in 18 ICU patients, we tested an experimental polyvinylchloride (PVC) tube, softer than those commercially available. Six of the 18 patients managed to "extubate" the trachea without using their hands, and despite firm fixation of the tubes to the face. On inspection, the six tubes were all found to be either looped in the mouth and pharynx or tortuously deformed. At that time, the mechanisms of tracheal tube dislocation were believed to include chewing, coughing, bucking, "tongueing," and moving the head. Because of the problem, the manufacturer was advised not to produce this soft PVC tube or to modify it to avoid this dangerous complication. More recently, however, patients in our intensive care unit have had similar spontaneous dislocations of commercially available PVC tubes. Two of these cases are reported here, and the likely causes of dislocation discussed, based on observations during experimental ventilation of a lung model and of cadavers.

REPORT OF TWO CASES

Case 1. A 56-year-old white man was hospitalized for elective total colectomy because of uncontrolled ulcerative colitis, unresponsive to medical therapy. Colectomy was uncomplicated, but during the first two postoperative days, severe respiratory distress developed. Roentgenograms of the chest revealed dense pulmonary infiltrates. At bronchoscopy, a large quantity of purulent material was removed. It grew Pseudomonas aeruginosa. The patient's condition deteriorated, and he was admitted to the intensive care unit for mechanical ventilation. A PVC tracheal tube, 8.5 mm I.D. was inserted orally under direct vision without difficulty. The cuff was seen to pass well below the vocal cords. Roentgenograms of the chest showed the tube in good position. The tube was secured to the face using tincture of benzoin and adhesive tape. Three hours later, an air leak developed. The tube was still firmly fixed to the face but distorted in the mouth, the cuff completely above the cords. This tube was removed, a second tube placed, and the cuff was again seen to pass below the cords. Exit of air from the tube was ascertained by pushing on the chest. The cuff was inflated with air until it just sealed. Breath sounds were heard by two examiners to be equal on both sides. Once more, the tube was removed. A postcardiopulmonary resuscitation portable chest x-ray film showed the cuff in the third tracheal tube 4 cm above the carina. Ventilation with a tidal volume of 1,000 ml and a positive end-expiratory pressure (PEEP) of 5 cm H2O caused peak airway pressure to oscillate between 30 and 35 cm H2O. Another roentgenographic examination 8 hours after cardiopulmonary resuscitation.