MANDIBULOHYOID DISTANCE IN DIFFICULT LARYNGOSCOPY

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SUMMARY
We studied radiographically 11 patients in whom direct laryngoscopy proved difficult and 100 control (general population) subjects. The vertical distance between the mandible and the hyoid bone (mandibulohyoid distance) was measured and the positions of the mandibular angle and hyoid bone determined in relation to the cervical vertebrae. We found that the mandibulohyoid distance was substantially longer in patients whose trachea was difficult to intubate: the mandibular angle tended to be positioned more rostrally in both men and women, and the hyoid bone tended to be positioned more caudally in women. This suggests that a relatively short mandibular ramus or a relatively caudal larynx may be important, unfavourable anatomic factors in difficult laryngoscopy. (Br. J. Anaesth. 1993; 71: 335-339)

KEY WORDS

Although difficult intubation continues to cause morbidity and mortality associated with anaesthesia, the reasons for difficult laryngoscopy have not been completely identified or explained. In the past, difficult intubation was attributed to several unfavourable anatomical factors such as receding mandible, protruding upper incisors and long maxilla, limited mobility of the temporomandibular joint [1,2], small atlanto-occipital gap [3,4], restricted pharyngeal space, and reduced submandibular tissue compliance [5]. Difficult laryngoscopy apparently is associated with one or more of these factors. Our study was designed to investigate the aetiology of difficult laryngoscopy in 11 patients with documented problems and to define a possible predictive indicator, mandibulohyoid distance.

SUBJECTS AND METHODS
We obtained lateral cervical radiographs of 11 patients in whom intubation during routine surgical procedures was found to be difficult (conventional rigid laryngoscopy by experienced anaesthetists failed). For clinical comparison, we also included one radiographic study of a patient with a severely receding jaw and protruding upper incisors ("buck" teeth), in whom laryngoscopy was anticipated as difficult before anaesthesia but was performed without difficulty.

The lateral cervical x-rays were taken with the head in the neutral position and the mouth closed. The atlanto-occipital gap was measured from the upper margin of the posterior tubercle of atlas vertically upward to the occiput. The rostro-caudal positions of the mandibular angle and hyoid bone were determined by horizontal extension to the corresponding levels of the cervical vertebrae (fig. 1). The mandibulohyoid distance, defined as the vertical distance between the mandible and the hyoid bone,
was measured from the upper margin of the hyoid bone vertically upward to the lower margin of the mandible. Radiological findings are summarized in table I. Because none of our subjects had a prominent long maxilla or temporomandibular joint problems, we did not include assessment of these two factors in our study.

In order to select a control group, we examined cervical spine x-ray films (taken by the radiology department during a 2-month period) in which the patient's head was in the neutral position; we excluded films of paediatric and edentulous patients. We measured the mandibulohyoid distance and determined the positions of the mandibular angle and the hyoid bone in 100 patients (54 male).

All data collected from our control and study subjects were analysed using appropriate statistical tests.

RESULTS

Difference in mean mandibulohyoid distance between the study and control groups

Data were analysed separately by gender, using a two-sided t test; the level of significance was α = 0.05. The difference between mean mandibulohyoid distances in male study subjects (mean 33.8 (SD 8.4) mm) and male control subjects (mean 21.4 (8.6) mm) was significant (P = 0.0013), as was that between female study subjects (26.4 (7.3) mm) and female control subjects (15.4 (6.3) mm) (P = 0.0006); this reflected a wide variation in mandibulohyoid distances in the general adult population. Patients in whom the trachea was difficult to intubate, however, tended to have a relatively longer mandibulohyoid distance (fig. 2).

Association of mandibulohyoid distance with vertebral levels of mandibular angle and hyoid bone (table II)

Linear regression models including as covariates vertebral levels for both the mandibular angle and hyoid bone were used to test statistical significance of associations with mandibulohyoid distance. In women, both relatively "rostral" mandibular angle (middle C2 and above) and relatively "caudal" hyoid bone (middle C4 and below) were associated with longer distance; the association was stronger for the hyoid bone (P = 0.0001) than for the mandibular angle (P = 0.0121). In men, longer distance was associated with relatively rostral mandibular angle (P = 0.0003), but not with the position of the hyoid bone. Therefore, although the mandibular angle was generally situated at the lower C2 level and the hyoid bone between the C3 and C4 levels (fig. 3), in

![Table I. Radiological findings. AOG = Atlanto-occipital gap; MH = mandibulohyoid. Unfavourable anatomical factors: t = small atlanto-occipital gap; 2 = rostral mandibular angle (short mandibular ramus); 3 = caudal hyoid bone (caudal larynx). * Patient in whom intubation was anticipated as difficult but was performed without difficulty.](BRITISH JOURNAL OF ANAESTHESIA)
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TABLE II. Mean (SD) mandibulohyoid distance (MHD) by vertebral levels of the mandibular angle and hyoid bone for the study (n = 11) and control groups (n = 100) combined

<table>
<thead>
<tr>
<th>Vertebral level</th>
<th>No. MHD (mm)</th>
<th>No. MHD (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Men (n = 60)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandibular angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle C2 and above</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Lower C2 to C3</td>
<td>41</td>
<td>34</td>
</tr>
<tr>
<td>Upper C3 and below</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Hyoid bone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower C3 and above</td>
<td>13</td>
<td>23</td>
</tr>
<tr>
<td>C3 to C4, upper C4</td>
<td>38</td>
<td>22</td>
</tr>
<tr>
<td>Middle C4 and below</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td><strong>Women (n = 51)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mandibular angle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle C2 and above</td>
<td>11</td>
<td>22.2 (8.1)</td>
</tr>
<tr>
<td>Lower C2 to C3</td>
<td>34</td>
<td>14.9 (5.9)</td>
</tr>
<tr>
<td>Upper C3 and below</td>
<td>6</td>
<td>15.3 (7.2)</td>
</tr>
<tr>
<td>Hyoid bone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower C3 and above</td>
<td>23</td>
<td>14.1 (5.4)</td>
</tr>
<tr>
<td>C3 to C4, upper C4</td>
<td>22</td>
<td>15.7 (5.4)</td>
</tr>
<tr>
<td>Middle C4 and below</td>
<td>6</td>
<td>28.8 (6.3)</td>
</tr>
</tbody>
</table>

**Distributions of mandibular angle and hyoid bone position**

The proportion with relatively rostral mandibular angle and relatively caudal hyoid bone for the study

patients with relatively longer mandibulohyoid distance the mandibular angle tended to be situated more rostrally among both men and women, and the hyoid bone tended to be situated more caudally among women.
Fig. 4. Lateral cervical x-ray film of patient No. 1 (male) shows unusually long mandibulohyoid distance (45 mm), unusually short mandibular ramus (mandibular angle is situated at upper C2 level) and occiput in contact with atlas in neutral position (atlanto-occipital gap = 0 mm). Note that a large portion of tongue mass is situated in the hypopharynx.

Fig. 5. Lateral cervical x-ray film of patient No. 12 (female) shows buck teeth and receding jaw. Mandibulohyoid distance (14 mm), mandibular angle (at lower C2 level) and hyoid bone (at lower C3 level) are relatively normal. Intubation was not difficult.

group was compared with that of control subjects using Fisher's exact test. The study group had a larger proportion with rostral mandibular angle in both men ($P = 0.0001$) and women ($P = 0.0006$). The proportion with a relatively caudal hyoid bone was larger for the study group in women ($P = 0.0009$), but not in men. This analysis suggested further that patients who presented difficulty in intubation, tended to have a relatively rostral mandibular angle; although a relatively caudal hyoid bone was also found significant for women in this group.

**DISCUSSION**

Because it measures the vertical distance between the mandible and the hyoid bone, the mandibulohyoid distance also indicates the relative rostro-caudal positions of the two. A more rostral mandibular angle, a more caudal hyoid bone, or both, contribute to a longer mandibulohyoid distance.

The ramus of the mandible articulates rostrally with the base of the skull at the mandibular fossa and extends caudally into the cervical region. A more rostral mandibular angle thus indicates a relatively short mandibular ramus. Because the epiglottis arises from the thyroid cartilage and then remains dorsal to the hyoid bone, the position of that bone marks the entrance to the larynx. A more caudal hyoid bone thus indicates a relatively caudal larynx.

**Role of a long mandibulohyoid distance in difficult laryngoscopy**

In the neutral head position, the oropharyngo-laryngeal passage has two axes which form an angle of almost 90° [6]. During normal laryngoscopy, we first convert that angle to about 125° by extending the head at the atlanto-occipital joint, and then use the laryngoscope blade to displace the tongue and establish a 180° straight-line alignment.

Basic geometric principles show that a small atlanto-occipital gap, protruding upper incisors and a long maxilla, a caudal larynx, or a combination of any of these anatomical factors, necessitate a greater degree of tongue displacement. If the submandibular tissue compliance is sufficient to compensate for these unfavourable factors, tongue displacement is not difficult; otherwise, difficulty may be anticipated.

A short mandibular ramus raises the floor of the oral cavity toward the base of the skull. Minor reduction in the linear vertical length of the mandibular ramus may substantially reduce the size of the oropharyngeal cavity, diminishing the space available for tongue displacement and thus contributing greatly to overall reduction of submandibular tissue compliance during laryngoscopy. When the position of the hyoid bone is caudal or is relatively caudal because of a short ramus, a large portion of the tongue is situated in the hypopharynx instead of in the oral cavity (fig. 4). During laryngoscopy, this large hypopharyngeal tongue mass further compromises the compliance needed for its displacement. The effects of a short mandibular ramus and a caudal hyoid bone explain the difficult intubation in patients Nos 4 and 11, who had no other indicators of a difficult laryngoscopy.
Comparative observations

Thyromental distance and horizontal length of the mandible are often used to assess the mandibular space and serve as a predictor for difficult laryngoscopy [7]. However, when this assessment was applied to patients Nos 1 and 12, both of whom had a severely receding jaw, it contradicted the clinical findings: in patient No. 1, who had an unusually long mandibulohyoid distance (45 mm), thyromental distance was 7.5 cm (i.e. > 6 cm) and horizontal length of the mandible was 7.5 cm (i.e. < 9 cm); in patient No. 12 (fig. 5), who had a relatively normal mandibulohyoid distance (14 mm), thyromental distance was 5.5 cm (i.e. < 6 cm) and horizontal length of the mandible was 7.8 cm (i.e. < 9 cm), but intubation was not difficult.

These findings may be explained as follows. First, thyromental distance, which is measured obliquely, is greatly affected by the vertical mandibulohyoid distance; patients in whom the mandibulohyoid distance is long tend also to have a long thyromental distance (patient No. 1).

Second, the micrognathic mandible, which may be deficient in width and length in both the body and the ramus, manifests clinically as a receding jaw, a short ramus, or both [8]. Although micrognathic patients often present difficulty in intubation, a short ramus may be a more important contributing factor than a receding jaw (for example, in patient No. 12, who had a relatively normal ramus, intubation was not difficult in spite of a severely receding jaw).

Unlike a receding jaw, a short mandibular ramus is a more subtle physical feature, and difficult intubation is often not suspected before anaesthesia (as in patient No. 4), although such a patient may be perceived as having low-set ears and a long neck.

An increased distance between the mandible and hyoid bone was referred to by Riley and colleagues [9] as “long MP-H", indicating a possibly inferiorly positioned hyoid bone. These authors described its role in cephalometric analysis for evaluating the obstructive sleep apnoea syndrome. Although the measurement was made differently from ours, it probably signified the presence of a similar anatomical deficiency (short mandibular ramus, caudal hyoid bone, or both), which results in difficult intubation.

In summary, difficult laryngoscopy is caused by complex dynamic interaction of many anatomical factors which aggravate or compensate for each other. If a favourable anatomical factor (such as an edentulous condition) exists, even an unusually long mandibulohyoid distance may not result in difficult laryngoscopy. However, a normal ramus or hyoid bone does not preclude difficult intubation if other unfavourable anatomical features are present (as in patient No. 5).

Preoperative examination is needed to quantify the combined effects of all unfavourable factors, including the short mandibular ramus and caudal larynx we have described. The mandible and hyoid bone are easily identified anatomical landmarks at radiological or physical examination. A long MH distance may be an additional clinical indicator for anticipating difficult intubation.

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REFERENCES