ULTRASOUND ASSESSMENT OF THE POSITION OF THE TONGUE DURING INDUCTION OF ANAESTHESIA†

L. J. ABERNETHY, P. L. ALLAN AND G. B. DRUMMOND

SUMMARY
Tongue position was assessed in 15 female patients at induction of anaesthesia with either thiopentone or propofol. A video recording of a midline sagittal section of the tongue was made using an ultrasound transducer placed below the chin, and representative figures analysed by an observer who was not aware of the patient’s state. In 11 satisfactory recordings, the tongue movement was inconsistent in direction and not more than 8 mm in the anterior tongue and 6 mm in the posterior tongue. The movements detected did not suggest that the tongue is likely to be an important cause of airway obstruction on induction of anaesthesia.

KEY WORDS

Maintenance of a patent airway is a common and occasionally difficult problem in general anaesthesia. Airway obstruction is often attributed to “falling back” of the tongue [1], resulting in occlusion of the oropharynx, but studies in man and animals indicate that obstruction may be caused in other ways, such as by pharyngeal collapse or by the epiglottis [2, 3]. The present study was undertaken to measure tongue movement during induction of anaesthesia using real-time ultrasound scanning, to assess the likelihood that tongue displacement could cause obstruction.

PATIENTS AND METHODS
This study was a within-subject, observer-blind comparison of tongue movement during induction of anaesthesia. It was approved by the local Ethics Advisory Committee. Fifteen female patients (ASA physical status I or II), who were about to undergo general anaesthesia for minor gynaecological operations, gave informed consent. Each patient was given temazepam 20 mg orally for premedication. Before induction of anaesthesia, the patient relaxed on the trolley with her head in a natural position (not extended) on a single pillow. An i.v. cannula was inserted. A continuous, real-time ultrasound image of the tongue was obtained using a 3.5-MHz mechanical sector-scanning transducer (Siemens Sonoline SX). The transducer was placed below the chin, without altering the position of the head or extending the neck, and positioned to give a good sagittal image of the tongue (fig. 1). The probe was clamped into position with a universal clamp fixed to the trolley, and no further adjustment of the position of the probe was made during the study.

Anaesthesia was induced by i.v. injection of thiopentone or propofol, given over about 30 s, to loss of the lash reflex. The real-time ultrasound image of the tongue was recorded on video, commencing before injection and continuing until at least 1 min after loss of consciousness. Clinical signs of airway obstruction, and the presence of apnoea without ventilatory effort, were noted if possible.

In order to assess tongue movement without observer bias, the images were interpreted in the following way. The video tape recording of the whole sequence was replayed by one observer. Single frames which showed a good image of the whole of the tongue were selected. For each
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Fig. 1. A: Photograph of sagittal ultrasound image of tongue. The anterior part of the image is on the left. B: Diagram of corresponding sagittal section through the mouth and pharynx showing position of ultrasound image.

Patient, two frames were selected before induction and two after induction. If tongue motion was present in phase with ventilation, frames were selected at end-expiration, which could be identified with ease. Photographs were taken of each of these frames, and each pair of photographs for a particular patient in a particular state was given a random code number. The photographs were presented to a second observer, who used each pair of frames to trace a single average outline of the tongue as an arc representing its upper and posterior surface.

Because the tracings for each state were of different lengths of the arc, measurement of tongue movement was made by directly comparing tracings of the images obtained before and after induction. The observer who made this comparison remained unaware of the patient state for each tracing. The common sector along which the tongue surface was identified clearly in both tracings was marked (fig. 2) and measurements made along the radius of the sector to its anterior, middle and posterior points, to the nearest 0.5 mm. The code was then broken, and measurements were related to patient state. Tongue movement was calculated as the difference between radius measurements at each point, and corrected for the scale settings of the imaging system. Data were analysed statistically with binomial distribution [4].

An increase in the radius was termed a cranial movement, and a reduction in the radius was termed a caudal movement. However, these are radial measurements and include a vector in the anterior-posterior dimension. As the centre of the field of view of the transducer was generally close to the cranio-caudal axis of the head, “caudal” movements of the anterior tongue include a posterior component, and “cranial” movements of the posterior segment include an anterior component.

RESULTS

In four patients it was not clear if apnoea was central or caused by airway obstruction and satisfactory data were obtained in 11 patients (table I). In the other patients, the ultrasound

Fig. 2. Tracings of positions of the tongue surface and measured dimensions.
Table I. Details of patients studied

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age (yr)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>Agent</th>
<th>Dose (mg)</th>
<th>Airway patency</th>
<th>Sector studied (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39</td>
<td>155</td>
<td>73</td>
<td>Thiopentone</td>
<td>375</td>
<td>Obstructed</td>
<td>57</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>160</td>
<td>59</td>
<td>Propofol</td>
<td>150</td>
<td>Obstructed</td>
<td>41</td>
</tr>
<tr>
<td>3</td>
<td>33</td>
<td>160</td>
<td>53</td>
<td>Thiopentone</td>
<td>250</td>
<td>Patent</td>
<td>63</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>157</td>
<td>76</td>
<td>Thiopentone</td>
<td>300</td>
<td>Obstructed</td>
<td>43</td>
</tr>
<tr>
<td>5</td>
<td>48</td>
<td>163</td>
<td>51</td>
<td>Propofol</td>
<td>100</td>
<td>Apnoea</td>
<td>72</td>
</tr>
<tr>
<td>6</td>
<td>55</td>
<td>165</td>
<td>62</td>
<td>Propofol</td>
<td>120</td>
<td>Patent</td>
<td>64</td>
</tr>
<tr>
<td>7</td>
<td>46</td>
<td>161</td>
<td>57</td>
<td>Propofol</td>
<td>80</td>
<td>Uncertain</td>
<td>60</td>
</tr>
<tr>
<td>8</td>
<td>39</td>
<td>178</td>
<td>73</td>
<td>Propofol</td>
<td>80</td>
<td>Uncertain</td>
<td>42</td>
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<td>Patent</td>
<td>65</td>
</tr>
<tr>
<td>10</td>
<td>28</td>
<td>150</td>
<td>57</td>
<td>Propofol</td>
<td>90</td>
<td>Uncertain</td>
<td>71</td>
</tr>
<tr>
<td>11</td>
<td>42</td>
<td>161</td>
<td>50</td>
<td>Thiopentone</td>
<td>200</td>
<td>Uncertain</td>
<td>76</td>
</tr>
</tbody>
</table>

Fig. 3. Results: measurements of movement of the anterior, middle, and posterior portions of the tongue on induction of anaesthesia.

Images did not show an adequate degree of sector of the tongue. In general, the posterior part of the tongue was more difficult to image because of the acoustic shadow cast by the hyoid bone. The angle of sector analysed was more than 55° in eight of the 11 patients whose data are reported (mean in all 11 patients 59° (SD 12°)).

In the awake patients there was no movement of the tongue in relation to ventilation. On induction of anaesthesia, the movements observed (fig. 3) were small. The greatest movement was 8 mm caudad, which occurred in the anterior tongue. There was no consistent direction of movement. The probability of any movement of more than 8 mm lies between 0 and 28% (95% confidence limits, binomial distribution). In those patients in whom clinical signs of airway obstruction were identified, no consistent movement of the tongue occurred on induction of anaesthesia. In some patients, however, airway obstruction was associated with caudad movement of the posterior tongue towards the hypopharynx with each inspiratory effort (fig. 4). There was no consistent difference in the changes observed that could be attributed to the two induction agents used (table II).

Table II. Mean (SD) of tongue movements in patients given thiopentone (n = 5) and propofol (n = 6)

<table>
<thead>
<tr>
<th></th>
<th>Anterior</th>
<th>Middle</th>
<th>Posterior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiopentone</td>
<td>0 (0)</td>
<td>-0.3 (1.4)</td>
<td>-0.8 (2.2)</td>
</tr>
<tr>
<td>Propofol</td>
<td>2.1 (2.5)</td>
<td>0.3 (1.6)</td>
<td>-0.2 (1.7)</td>
</tr>
</tbody>
</table>

DISCUSSION

Tongue position during anaesthesia has been investigated previously using radiography [1]. We have used ultrasound to image the tongue, principally to avoid the use of ionizing radiation. In addition, ultrasound may be used to construct a continuous, real-time image of the tongue over the period of induction. The ultrasound transducer was clamped below the chin to make gentle contact with the skin, so that the patient's head remained in a natural, relaxed position. However,
it is possible that the transducer may have restrained jaw position to some extent, as muscle tone changed with loss of consciousness.

Ultrasound scanning produces a sagittal, cross-sectional image without the problem of overlapping structures produced on a lateral radiograph. The magnification and geometric distortion associated with conventional radiography are also avoided. There are, however, disadvantages in the use of ultrasound: ultrasound is reflected almost completely at an air–tissue interface, and so the position of the soft palate, epiglottis and posterior wall of the pharynx cannot be determined, and thus the dimensions of the airway itself cannot be judged. A dense acoustic shadow is cast by the hyoid bone, which in some patients limits imaging of the posterior tongue. Ultrasound scanning of the tongue has been used in a similar manner to evaluate tongue movement during speech [5] and swallowing [6].

The tongue image obtained was commonly in the form shown in figure 1, with a curvature convex in the cranial direction. The segment of the tongue observed was in the midline sagittal plane, but the direction of sight of the transducer was moved in this plane to obtain the best image. No attempt was made to measure the exact orientation of this direction, although generally it remained approximately parallel with the cranio-caudal axis of the head. Consequently, measurements were made of movements of the tongue surface towards or away from the transducer, and these do not imply an exact relationship to body axes. For example, it is clear from figure 1 that a caudad movement in the posterior tongue also reflects a movement anteriorly. The exact apportionment of these vectors is not possible. In addition, measurement was made only of the intersection of the tongue surface with the radius chosen; in the event of a change in tongue position, this intersection may not represent the same spot on the tongue surface. For these reasons, attempts to express tongue movement in exact anatomical directions were not considered realistic. The image considered was only of the midline sagittal section of the tongue. The tongue is curved also in the coronal plane, and a small reduction in this degree of curvature could cause apparent caudal movement of the image, with no true displacement of the mass of the entire tongue. Our observations depend, therefore, on the assumption that the overall shape of the tongue is not altered greatly.

Pressure from the transducer may have caused distortion and restriction of movement of the tongue. However, the influence of transducer pressure on tongue shape could be assessed easily by observing movement of the tongue as the transducer system was adjusted, and care was taken to minimize this influence.

Observed movement of the tongue during induction was small, the maximum being 8 mm caudal in the anterior part of the tongue in one patient. Maximum movement in the posterior tongue was 6 mm. These results compare with maximum movements of about 15–20 mm during swallowing observed with radiography [7] or ultrasound [Abernethy, unpublished data]. Overall, the results showed no consistent direction of movement. In two patients, caudal movement of the posterior tongue with each inspiratory effort was noted when airway obstruction was evident clinically. This observation would not be expected if airway obstruction were caused by posterior movement of the tongue, but is consistent with inspiratory effort against an airway which is occluded caudal to the tongue. Recent studies [3] using fibreoptic endoscopy have suggested that this is a common event. In normal subjects during natural sleep and in patients with sleep apnoea syndrome, airway obstruction can occur in some individuals at the soft palate, and in others in the hypopharynx [8, 9]. During anaesthesia, similar variation between individuals of the site of obstruction is likely.

Whilst our patients were awake, motion of the tongue in relation to ventilation was not observed. Some studies of tongue electrophysiology have shown phasic activity [10, 11], but in others the action in genioglossus was predominantly tonic [12, 13]. In addition, the use of premedicant or sedative drugs may reduce the activity of the tongue muscles [14]. However, it is possible that even if phasic muscle activity were present, this could act merely to maintain the position of the tongue against the changing pressure within the mouth.

Movement of the tongue in its posterior part would be most likely to cause obstruction of the pharynx. In our study, posterior movement of the posterior tongue would cause an increase in the distance measured along a radius from the centre of the image sector, and this would be expressed in our results as a cranially directed movement, although the direction has both cranial and posterior components. Such a movement occurred
in only three patients and the greatest movement was 3.2 mm. The direct posterior component of this movement would be only a fraction of this, and is less than would be expected to cause obstruction on the basis of previous measurements. For example, in awake supine subjects, the distance from the posterior wall of the tongue to the posterior pharyngeal wall is about 10 mm (range 4.5–14 mm) [15].

In patients with sleep apnoea (in whom pharyngeal dimensions may be less than normal), the anteroposterior dimension of the pharynx posterior to the tongue is about 13 mm in the supine patient [16]. On induction of anaesthesia in elderly male subjects, posterior movement of the tongue of 6.4 mm was insufficient to cause contact with the posterior pharyngeal wall [17]. Consequently, we believe that the small, inconsistent changes in tongue position which we noted were unlikely to contribute significantly to airway obstruction after induction of anaesthesia.

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REFERENCES