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AIRWAY PATENCY IN THE UNCONSCIOUS PATIENT

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SUMMARY

Airway patency was explored in patients breathing spontaneously under deep halothane anaesthesia. Opening and closing of the airway was observed with a flexible bronchoscope looking proximally from the nasopharynx at the epiglottis and the tongue. With the occiput elevated at various angles the smallest angle of retroflexion of the neck necessary to open the airway was measured. The influence of artificial airways on this angle of retroflexion was measured. Cadaveric preparations of the upper airway were studied to assess the mechanisms involved in airway patency. The results indicate that the epiglottis and not the tongue is the main cause of obstruction of the upper airway. When methods are applied to displace the hyoid anteriorly, the airway will be cleared on most occasions.

Unconsciousness may lead to asphyxia from obstruction of the upper airway. To overcome such airway obstruction, forward displacement of the mandible was recommended first over a century ago Heiberg (1874). In 1956 Finck described passive closure of the glottis, which occurred in relatively deep anaesthesia and was initiated by the inspiratory gasflow when the Bernoulli effect was unopposed by abduction of the vocal cords. However, Shelton and Bosma (1962) showed that a pharyngeal airway was maintained, in conscious babies, despite changes in posture or movements of the pharyngeal structures. Even when the tongue was pushed backwards forcibly, an airway could be maintained in all babies. They concluded that the relative position of the mandible, hyoid and sternum, and their relation to the 6th cervical vertebra, were maintained because of traction on the hyoid bone by the submandibular muscles only.

The purpose of this study was to determine whether obstruction of the upper airway was primarily a result of the tongue falling back, or if another mechanism was responsible for airway closure in the unconscious patient.

PATIENTS, MATERIALS AND METHODS

Anatomical preparations

The relationships of the pharynx, larynx, hyoid bone and the tongue were studied in six fresh cadaver preparations, which were fixed later in formaldehyde and preserved in alcohol.

Patients

Twenty patients (11 male) (ASA 1) scheduled for minor operations on the extremities were selected for study. Most were young (mean age 33 yr, range 18–62 yr), of average constitution and free from any disease of the air passages or lungs. Three patients had a dental prosthesis which was removed during the study. Each patient gave informed consent before entering the study.

Anaesthesia was induced with thiopentone 4 mg kg^{-1} i.v., followed by spontaneous breathing of a mixture of oxygen, nitrous oxide and halothane from a well-fitting face mask via a circle system. A fresh gas flow of 1.5 times the patient's estimated minute volume was used. The depth of anaesthesia was maintained at Guedel stage 3–2 without additional opioids. The patients were in a supine position on a flat operating table. Neuromuscular blocking drugs were not given.

A flexible bronchoscope (Olympus, type BF-B3R) with an operative length of 60 cm and a diame-

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ter of almost 6 mm, was passed through a hole in the face mask via the nose and into the naso–pharynx. No leak of gas was allowed and the expired volume was measured breath-by-breath (Dräger Volumeter). The angle of retroflexion was recorded as the angle between the horizontal plane of the operating table and the line connecting the lateral corner of the eye and the tragus of the ear. The angle subtended by the head in the neutral position without manipulation was recorded initially, then the head was extended slowly with the mouth closed until a free airway was established (fig. 1). A clear airway was indicated by the expired tidal volume becoming maximal. This manipulation was repeated with an oral (mouth open) and a nasal pharyngeal airway (mouth closed) in place. The first measurements were undertaken without elevation of the occiput. All measurements were then repeated with pillows to produce a 4- and 8-cm elevation of the occiput above the operating table. During the measurements the flexible bronchoscope remained in position behind the uvula, looking proximally at the structures in the mouth, the vocal cords and the epiglottis. The bronchoscope could be advanced in the direction of the lower pharynx when necessary.

Statistical analysis of the angles of retroflexion was performed using Student's t test for paired values. Measurements with and without the artificial airways were compared, and measurements at various heights of the occiput (above the table) were compared with elevation of the occiput to 4 cm.

RESULTS

Anatomical preparations

In the cadaveric preparations it was obseved that the tongue did not usually reach to the posterior pharyngeal wall, because it was attached mainly to the posterior aspect of the mandible at the chin. When the tongue of the cadaver was pushed forcibly into the mouth, obstruction occurred mainly at the level of the soft palate—by closure of the natural oral airway. When more pressure was exerted, the natural nasal airway was occluded also, the soft palate being pushed against the posterior pharyngeal wall. In the lower pharynx, two mechanisms of obstruction occurred—which were independent of manipulation of the tongue. The base of the epiglottis closed over the trachea and the rims of the epiglottis came into contact with the posterior pharyngeal wall and could close the respiratory tract. The visible part of the epiglottis, the pars glottica, could extend into the oesophagus and so protect the interarytenoid fold from contamination with foreign material. In one cadaveric preparation the tongue was removed from the hyoid bone and it was

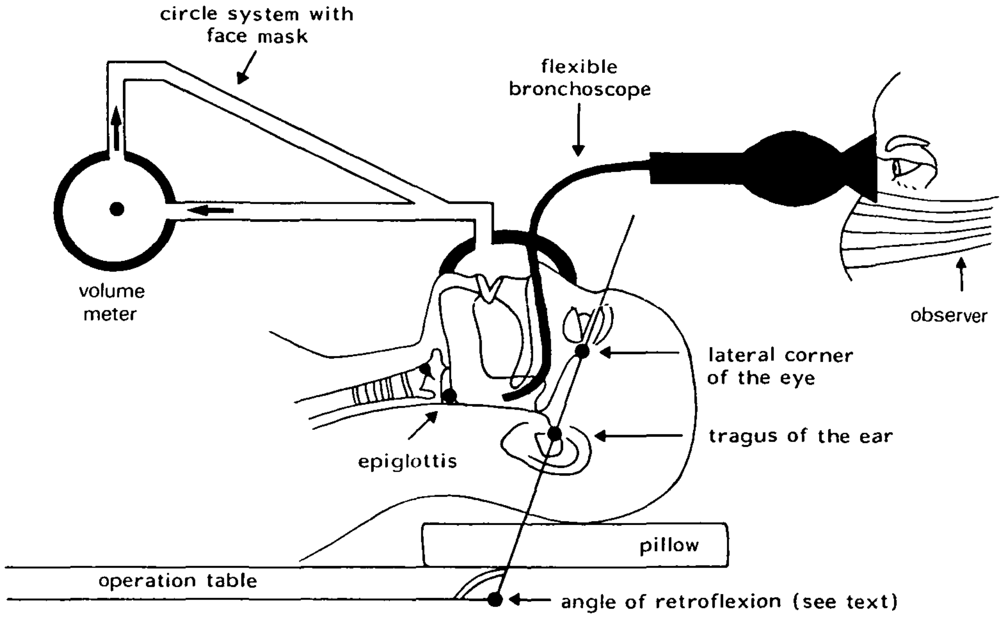

FIG. 1. The breathing circuit, flexible bronchoscope, pillows and landmarks (•) used in this study to measure the position of the patient's head and to observe the mechanism of airway closure.

TABLE I. *Angles of retroflexion of the head (mean (SD)) in 20 patients. Significance calculated with the t test for paired values: conditions compared with the "no-adjunct" group — †P < 0.001; elevations of 0 and 8 cm compared with the values measured at 4 cm — **P < 0.01; ***P < 0.001*

	Upper airway closed	Upper airway clear		
Elevation of occiput	Neutral position	No adjunct	Oral airway	Nasal airway
0 cm	105 (9.1) † ***	114 (7.1) **	114 (5.5) ns **	112 (6.8) ns ***
4 cm	96 (6.5) †	109 (5.5)	110 (5.5) ns	106 (7.1) ns
8 cm	91 (2.3) † **	102 (8.2) ***	101 (9.3) ns ***	97 (10.8) † ***

observed that it was possible to obtain an airtight seal in the upper airway with the epiglottis alone.

The hyoid bone is horse-shoe shaped and can be moved in all directions by the action of the extrinsic pharyngeal muscles, although there is some restriction to movement in a caudal direction. The thyroid cartilage is suspended from the hyoid bone and it is fixed dorsally to the dorsal conjoined tendon of the pharyngeal muscles, which is in turn connected to the prevertebral fascia.

The epiglottis hangs, like the lid of a bin, from the posterior aspect of the hyoid with the thyro-epiglottic ligament acting as the hinge and the hyo-epiglottic ligament acting as the lever for the lid. In the cadaveric preparations it was demonstrated that the position of the epiglottis in the hypopharynx depended principally on the relative position of the hyoid in relation to the thyroid cartilage.

Patients

The angle of retroflexion (table I) necessary to open the airway was not altered substantially by the use of artificial airways in the hypopharynx. However, in eight of the 20 patients, with a nasopharyngeal airway at 8 cm elevation, and in one patient at 4 cm elevation, there was a small difference in the required angle of retroflexion compared with the angle in the neutral position. In these patients the nasal airway supported the epiglottis clear of the retropharyngeal wall. In the other patients the angle of retroflexion required to open the airway was significantly greater than that present in the neutral position. The angle of retroflexion, required to achieve a clear airway became smaller as the occiput was elevated, and once the airway began to open, only a little more tilt was required to open it fully (fig. 2).

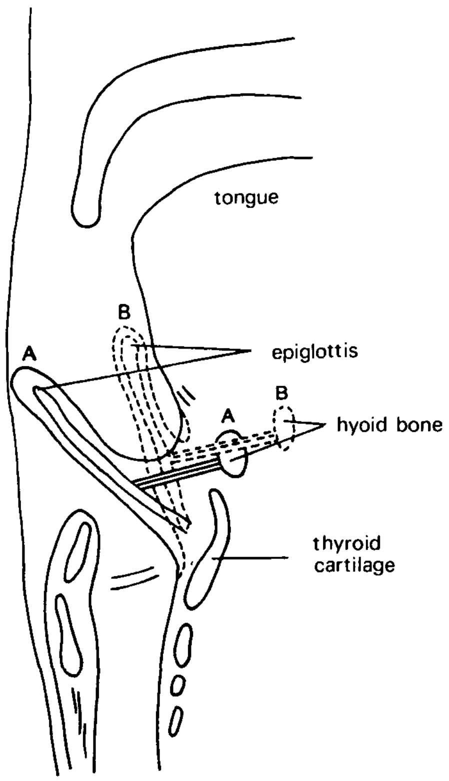

FIG. 2. Cross-section of the larynx, showing obstruction of the upper airway by the epiglottis (A). Anterior displacement of the hyoid bone by the extra pharyngeal muscles clears the airway (B).

The *mechanism* of airway closure was visualized using the flexible bronchoscope. With this method it could be demonstrated that the epiglottis was sucked over the entrance to the trachea by the inspiratory pressure and this occurred well before the tongue even approached the posterior pharyngeal wall. The airway was closed as the rims of the epiglottis reached the pharyngeal wall. When attempts were made to ventilate a patient with the epiglottis in this position, the pars glottica could be seen being forced into the oesophagus. The gas mixture might then enter the oesophagus and be passed into the stomach. As the head was extended the epiglottis was withdrawn from the tracheal entrance. When partial obstruction occurred and the top of the epiglottis vibrated in the lower pharynx, the characteristic snoring sound could be heard.

DISCUSSION

These observations indicate that the tongue is not the only factor concerned with upper airway obstruction. The mechanism is more complicated and it seems necessary to reconsider the facts. The data presented by Safar and colleagues (1959) were accurate, but their conclusion, that the tongue is the sole source of upper airway obstruction, is not wholly justified, as it has been shown that the airway may close even when the tongue is bypassed.

The hyoid bone can be considered as forming the boundary of the wide end of two funnels, the larynx and the pharynx, both of which are suspended from the base of the skull and extend into the thorax. Which funnel is opened/closed is determined by the position of the epiglottis which, in turn, depends on the antero–posterior position of the hyoid bone in relation to the thyroid cartilage. This position may be altered voluntarily by the extrapharyngeal musculature of the hyoid bone, whereas the thyroid cartilage remains rather immobile. It seems that the omohyoid muscle, and the anterior belly of the digastric muscle, are essential to manoeuvre the hyoid bone towards its ventral position. It is obvious that this does not occur in unconscious patients. For the same reason, it is probable that the triple airway manoeuvre (Morikawa, Safar and DeCarlo, 1961) remains the most successful method of opening the airway because this manoeuvre moves the hyoid ventrally. On the other hand, the introduction of a stomach tube and an oesophageal obturator airway should be assisted by flexion of the neck, to push the hyoid bone backwards.

This investigation showed that the airway is

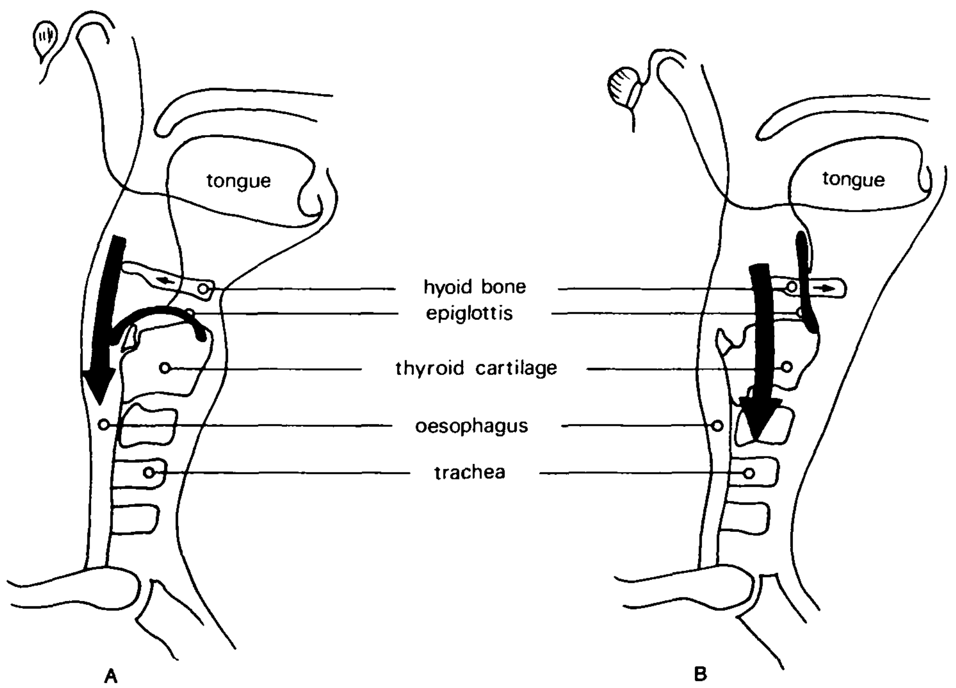

FIG. 3. The position of the hyoid bone determines which of two funnels is opened/closed. Note that the tongue is pushed away by the pressure of the epiglottis in position (B).

almost invariably closed when the head is in its neutral position, and that the use of artificial airways did not always guarantee a clear airway. The airway was clear when the nose or the mouth, or both were open, and the epiglottis did not reach to the posterior pharyngeal wall. The tongue may obstruct the upper airway in two ways. It may push the soft palate against the posterior pharyngeal wall, obstructing both the nasal and oral cavities. The tongue may close the oral cavity when the nose is obstructed, then acting as a one-way valve obstructing expiration. In both cases of obstruction by the tongue there is an indication for Mayo or Guedel type airways. Obstructions of this type were not seen during this study, but are occasionally noticed in patients with a dental prosthesis. The effect of opening the mouth with a Mayo airway does not decrease significantly the angle of retroflexion, nor does the introduction of artificial airways. Only the elevation of the head decreases the head tilt necessary to clear the airway. When the head is elevated, a nasal pharyngeal airway of sufficient length to support the epiglottis will often provide a clear airway and decrease the angle of retroflexion significantly. However, in these patients it was possible to obstruct the upper airway by flexion of the neck.

This concept of airway closure may contribute to the training of medical and paramedical personnel and explain the management of the airway and the use of artificial airways, stomach tubes and tracheal tubes. However, at present it does not seem prudent to give such complicated detailed information during the training of the lay public, although it may be possible to use a simplified version of this concept.

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