Relationship between difficult tracheal intubation and obstructive sleep apnoea

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Summary

The upper airway abnormalities predisposing to difficult tracheal intubation may also predispose to obstructive sleep apnoea (OSA). The potential association is important as both conditions increase perioperative risk and patients with a trachea that is difficult to intubate may need assessment for OSA. We determined if patients with difficult intubation are at greater risk of OSA and, if so, whether or not they have characteristic clinical or radiographic upper airway changes. We studied 15 patients in whom the trachea was difficult to intubate and 15 control patients. Each was evaluated clinically (Mallampati score, thyromental distance, neck circumference, head extension), polysomnographically (apnoea–hypopnoea index (AHI)) and radiographically (lateral cephalometry). AHI was greater in the difficult intubation group (mean 28.4 (SD 31.7)) compared with controls (5.9 (8.9)) (P < 0.02); eight of 15 patients in the difficult intubation group and two of 15 in the control group had an AHI > 10 (P < 0.03). Difficult intubation, but not OSA, was associated (P < 0.05) with a smaller thyromental distance and mandibular length, and greater soft palate length. Both difficult intubation and OSA were associated (P < 0.05) with a greater Mallampati score, anterior mandibular depth, and smaller mandibular and cervical angles. OSA, but not difficult intubation, was associated (P < 0.05) with increased neck circumference, tongue area and craniocervical angle, and decreased head extension, mandibular ramus length and atlanto-occipital distance. We conclude that difficult intubation and OSA are related significantly. They share anatomical features which act to reduce the skeletal confines of the tongue. Patients with OSA may compensate, when awake, by increasing craniocervical angulation, which increases the space between the mandible and cervical spine and elongates the tongue and soft tissues of the neck. (Br. J. Anaesth. 1998; 80: 606–611)

Key words: intubation tracheal, difficult; sleep apnoea; ventilation, apnoea; airway, anatomy; complications, obstructive sleep apnoea

Difficult tracheal intubation and obstructive sleep apnoea (OSA) are two common clinical problems which contribute to perioperative morbidity and mortality.1–3 The reported incidence of failed tracheal intubation is 1 in 2300 in non-obstetric patients and 1 in 300 in obstetric patients.4 OSA, characterized by repetitive partial or complete upper airway obstruction during sleep, has been estimated to affect 4% of men and 2% of women in middle age5 and has been identified as a major health problem as a result of associated greater daytime sleepiness,6 hypertension7–8 and increased risk of cardiovascular9,10 and cerebrovascular disease.11

Upper airway abnormalities have been described in both conditions. Clinically, a short thick neck,12 limited head extension13,14 and reduced thyromental distance15 have been associated with difficult tracheal intubation, and oropharyngeal crowding and greater neck circumference with OSA.16,17 A large tongue has been associated with both.16,18 Radiographic studies of upper airway structure using lateral cephalometry have demonstrated craniocervical and mandibulohyoid abnormalities in each condition19–23 but there has been no examination of their inter-relationship.

It has been suggested that in patients with OSA, the trachea may be difficult to intubate2,24 and, conversely, those who have tracheas that are difficult to intubate may be at increased risk of OSA.20,25 Shared upper airway abnormalities could provide the basis for such an association. However, the relationship between the two conditions has not been studied formally and remains undefined. If difficult intubation indicates a predisposition to OSA, it would be important to be aware of it as prompt identification and treatment could prevent associated morbidity and mortality in the perioperative period and beyond. Hence the aim of this study was to determine if patients who present with difficult tracheal intubation are more likely to have OSA and, if so, what upper airway abnormalities are shared by the two conditions.

Patients and methods

After obtaining approval from the hospital Ethics Committee, we recruited subjects from the...
CLINICAL ASSESSMENT

Each subject was assessed clinically by a single observer (A. H.) before polysomnography and cephalometry. Oropharyngeal appearance was assessed using the modified Mallampati method. The subject sat upright with the head in the neutral position, the mouth fully open and the tongue maximally protruded, and was instructed not to phonate. The oropharynx was inspected from the subject’s eye level and the appearance classified as follows: class I, soft palate, fauces, uvula and tonsillar pillars visible; class II, soft palate, fauces and uvula visible; class III, soft palate and base of uvula visible; and class IV, soft palate not visible. Thyromental distance was measured from the thyroid prominence to the most anterior part of the chin, with the head fully extended.

External neck circumference was measured at the level of the cricothyroid membrane, with the head in the neutral position. Head extension at the atlanto-occipital joint was assessed by measuring the angle traversed by the occusal surface of the maxillary teeth, when the head was fully extended from a neutral position, using a goniometer.

POLYSOMNOGRAPHY

Sleep stage (electroencephalogram (C4/A1), right and left electro-oculogram and submental electromyogram), oronasal airflow (thermistor), ribcage and abdominal wall motion (inductance plethysmography), arterial oxyhaemoglobin saturation (pulse oximetry), electrocardiogram and sound were recorded on a digital polysomnograph (Ultrasom, Nicolet Biomedical, Madison, USA). The polysomnograph was analysed by an experienced technologist who was blinded to the intubation status of the subject. Sleep stage was scored using the criteria of Rechtschaffen and Kales. Apnoea was defined as cessation of oronasal airflow for more than 10 s. Continued ribcage and abdominal wall motion indicated that apnoea was of obstructive origin. Hypopnoea was defined as a reduction in oronasal airflow accompanied by reduction in arterial oxyhaemoglobin saturation of more than 4%. The apnoea–hypopnoea index (AHI) was calculated by dividing the total number of apnoeas and hypopnoeas by total sleep time.

CEPHALOMETRY

Lateral cephalometric radiographs were obtained using a standardized procedure. The awake, seated
subject was instructed to maintain natural head position by fixing a distant gaze on an imaginary horizon in order to obtain their customary visual axis. This head position was fixed using a cephalostat. To minimize radiation, exposure was adjusted to maximize the craniofacial and cervical skeletal, and soft tissues on a single radiograph. A radio-opaque lead acetate paper using standard anthropological and dentofacial landmarks. Measurements were made from these tracings using a calibrated digitizing tablet (Calcomp, Scottsdale, USA) connected to a personal computer. Reference points and measurements made are shown in figure 1.

DATA ANALYSIS

The association of sleep apnoea (defined as AHI ≥ 10) with difficult intubation was assessed using Fisher’s exact test. Clinical, polysomnographic and cephalometric variables were compared between the difficult intubation and control groups and between those with and without sleep apnoea (as defined above) using one-way analysis of variance. \( P < 0.05 \) was regarded as statistically significant.

Results

There were no significant differences between the difficult intubation and control groups in age (59.8 (range 40–76) and 53.0 (35–68) yr, respectively), height (171.3 (SD 7.0) and 170.5 (9.0) cm), weight (89.0 (13.6) and 83.3 (15.6) kg) or body mass index (30.8 (3.5) and 29 (3.1) kg m\(^{-2}\)). There were 15 males and two females in each group.

AHI was significantly greater \( (P < 0.02) \) in the difficult intubation (28.4 (31.7)) compared with the control group (5.9 (8.9)) (fig. 2). Apnoeas were predominantly obstructive in nature, with the proportion of obstructive or mixed obstructive/central apnoeas being 95.9 (6.4) % in the difficult intubation and 94.8 (10.7)% in the control group. Using an AHI of \( \geq 10 \) to define OSA, eight of 15 patients in the difficult intubation group had OSA, in five of whom it was severe (AHI > 40). Two of 15 control patients had OSA: one mild (AHI = 17.4) and the other moderate (AHI = 33.4). These differences were significant \( (P < 0.03) \).

Clinical and cephalometric variables (table 1, fig. 3) were divided into three distinct groups: those showing an association with difficult intubation, those associated with OSA or those associated with both. Those associated with difficult intubation alone included smaller thyromental distance and mandibular length, and greater posterior mandibular depth and soft palate length. Those associated with OSA alone included greater neck circumference, tongue area and craniocervical angle, and smaller head extension, atlanto-occipital distance and mandibular ramus length. Those that were associated with both difficult intubation and OSA included greater Mallampati score, anterior mandibular depth, lower mandibular angle, cervical angle and occlusal–goniohyoid angle (fig. 1). Mandibulohyoid distance was not significantly different in the difficult intubation and control groups and was not related to OSA.

Discussion

The major finding of this study was that difficult tracheal intubation was associated strongly with OSA. Patients presenting with difficult intubation had a greater occurrence and severity of OSA relative to the control group, even though we excluded two patients identified as having a trachea which was difficult to intubate because they were being treated for severe OSA. No one included in the control group had been diagnosed previously with OSA. While the possibility of a relationship between difficult intubation and OSA has been proposed by others, it has not previously been studied formally.
This relationship is important because untreated OSA could contribute to morbidity and mortality in the perioperative period and beyond.6–11 The strength of the relationship appears such that all patients who have a trachea that is difficult to intubate should be regarded as having OSA until excluded by the absence of clinical features (such as snoring, observed apnoeas and excessive daytime sleepiness) and, where doubt exists, sleep studies.16 Patients in which obvious craniofacial abnormalities were present were excluded from our study, so that predisposition to OSA or difficult intubation was not readily evident from superficial examination.

We examined upper airway characteristics associated with each condition believing that some would be common to both, forming the basis of their relationship, and others would be unique to each, accounting for the incomplete concordance between them.

Most of the skeletal and soft tissue changes which were associated with difficult intubation or OSA, or both, appeared to either decrease the skeletal confines of the tongue or compensate for such a decrease. Factors decreasing skeletal confines included: smaller mandibular length and greater posterior mandibular depth, in the case of difficult intubation alone; smaller mandibular ramus length, in the case of OSA alone; and greater anterior mandibular depth and lower mandibular angle, where both conditions were present. Decreasing the skeletal confines of the tongue acts to decrease the space available for anterior tongue displacement during direct laryngoscopy29 and to decrease hypopharyngeal dimensions,30 predisposing to OSA. Our findings are supported by other studies which have demonstrated lower and mid-face elongation in subjects with OSA.31 The findings are also consistent with studies suggesting that a deeper mandible and greater lower mandibular angle increase intubation difficulty because they diminish mouth opening and necessitate more anterior displacement of the tongue.12,19 Indeed a greater mandibular angle would increase the degree of posterior relative to downward displacement of the tongue with mouth opening, aggravating both difficulty in tracheal intubation and OSA (when the mouth is open).

The greater cervical angle and, in the case of OSA alone, greater craniofacial angle presumably compensate for this decrease in skeletal confines of the tongue. Their effect would be to increase the distance between the mandible and cervical spine and elongate the tongue and soft tissues of the neck, lifting the hyomandibular complex away from the cervical spine thereby increasing the airway space.32 This "sniffing the morning breeze" position, with forward inclination of the cervical spine and head extension, may be a wakeful postural compensation for upper airway narrowing. Anaesthetized patients are commonly placed in this position either to facilitate airway maintenance or aid tracheal intubation. Loss of this head posture during sleep with loss of skeletal muscle tone could be an important factor in the pathogenesis of OSA, in addition to the well recognized contribution of sleep-associated loss of pharyngeal muscle tone to upper airway narrowing.

The limited head extension observed with OSA may reflect the fact that the cervical and craniofacial angles are already increased so that the neck is already extended (see above), limiting further extension. This suggested mechanism has not been proposed previously, and is supported by the finding that atlanto-occipital distance is reduced in OSA patients. While we did not find an association between limited neck extension and intubation difficulty in our patients, others have,19 and the mechanism may be relevant to their findings, particularly as we demonstrated a greater cervical angle in the difficult intubation group.

The greater tongue area found on lateral cephalometry in OSA patients may reflect a true increase in tongue size or a change in tongue geometry consequent on a change in its skeletal confines. Either way, these changes could, together with changes in cervical angulation, contribute to the greater neck circumference observed in association with OSA patients. This finding is consistent with previous observations.17

The strong relationship between increased Mallampati scores and both difficult intubation and OSA may have a different basis in each condition. In the difficult intubation group, soft palate length was
greater, which would tend to increase Mallampati score. With OSA, mandibular ramus length was less, which would also increase Mallampati score by decreasing the distance between the floor of the mouth and soft palate. The Mallampati score is used widely to predict difficult intubation11 and should be explored further as a predictor of OSA.

The occlusal–goniohyoid angle (fig. 1) was related strongly to both difficult intubation and OSA. This angle, which has not been described previously, indicates posterior displacement of the larynx relative to the gonion. It is influenced by several factors related to facial morphology, including mandibular depth, length of the ramus, craniofacial angulation and position of the hyoid, which may explain the strength of its association with both conditions. It may be useful in cephalometry as an easily measured overall assessment of mandibular size and angulation.

The association of decreased thyromental distance with difficult intubation is another observation corroborated by the findings of others.10 Our data suggest that it may be attributable to a combination of smaller mandibular length, greater anterior and posterior mandibular depths, and an increased lower mandibular angle.

It is important to regard conclusions based on the anatomical associations described above cautiously, as they derive from multiple comparisons in the context of a relatively small number of patients. However, we offer them as “hypothesis generating” rather than “hypothesis proving” findings. They appear internally consistent, biologically plausible and many are supported by the findings of others. Several potential interactions between the variables have been referred to above, especially the influence of skeletal structure on the disposition of the soft tissues. Further studies are required to confirm these findings and such studies could allow measurements to be selected and equations generated to reliably predict difficult intubation or OSA, or both, from clinical and cephalometric variables.

In summary, this study showed that subjects in whom the trachea was difficult to intubate were at increased risk of OSA. Complex interrelated anatomical changes appear to be responsible for the association. Linear and angular changes in the mandible decrease the space available for air and instrumentation in the oropharynx. Patients with sleep apnoea appear to compensate for this, at least during wakefulness, by increasing craniofacial angulation. This postural compensation may be lost with muscle relaxation during sleep or when under the influence of sedatives, neuromuscular blocking agents or anaesthetic agents. Patients known or predicted to be difficult to intubate should be screened for signs and symptoms of sleep apnoea, with further investigation and treatment arranged where indicated, to minimize the morbidity associated with this condition both in the perioperative period and beyond.

References
28. Solow B. The pattern of craniofacial associations. A morpho-


