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Difficult laryngoscopy and cephalometric roentgenograms in obstructive sleep apnea syndrome patients undergoing uvulopalatopharyngoplasty

Seiji Kato, Mariko Hoshino, and Fumio Goto

Department of Anesthesiology, Kitasato University School of Medicine, 1-15-1 Kitasato, Sagamihara, Kanagawa 228, Japan

Abstract: We retrospectively studied the incidence of difficult laryngoscopy in 53 subjects with obstructive sleep apnea syndrome (OSAS) undergoing uvulopalatopharyngoplasty (UPPP) and 72 subjects with chronic otitis media undergoing tympanoplasty (control group). The incidence of difficult laryngoscopy in the UPPP group was significantly higher than in the control group (18.9% *vs* 4.2%, $P < 0.001$). To analyze the anatomical findings of difficult laryngoscopy in UPPP patients, cephalometric roentgenograms were compared between patients in whom direct laryngoscopy was difficult (difficult patients, $n = 10$) and patients in whom direct laryngoscopy was not difficult (nondifficult patients, $n = 43$). Cephalometric atlanto-occipital distance (cAOD) was less than 4 mm in 80% of the difficult patients, and there were significant differences between the difficult patients and the nondifficult patients (2.8 ± 3.3 mm *vs* 6.7 ± 3.0 mm, mean ± SD, $P < 0.001$). There were significant differences in cephalometric effective mandibular length/cephalometric posterior depth of mandible ratio (cEML/cPDM) between the difficult patients and the nondifficult patients (4.0 ± 0.6 *vs* 4.5 ± 0.8, $P < 0.01$); however, the calculation of cEML/cPDM was more difficult than cAOD. We concluded that OSAS patients undergoing UPPP are at high risk for difficult laryngoscopy, and that cAOD calculated from cephalometric roentgenograms is an easy and sensitive predictive indicator for the estimation of difficult laryngoscopy.

Key words: Obstructive sleep apnea syndrome, Cephalometric roentgenogram, Difficult laryngoscopy, Uvulopalatopharyngoplasty

Introduction

Uvulopalatopharyngoplasty (UPPP) is a surgical procedure for the treatment of obstructive sleep apnea syndrome (OSAS) [1]. The major clinical characteristics of OSAS are obesity, narrow middle pharynx, and macroglossia [1]. These anatomical characteristics are also the risk factors that cause difficult endotracheal intubation. Difficult intubation is the main cause of morbidity during anesthesia; therefore, it is important to examine these risk factors preoperatively in OSAS. We studied the incidence of difficult endotracheal intubation in a UPPP group and a tympanoplasty group (control group). Cephalometric roentgenograms were used to assess craniofacial abnormalities and upper airway patency associated with OSAS according to the Otolaryngological Society [2]. However, otolaryngologists have not used cephalometric roentgenograms for the analysis of difficult laryngoscopy [2–6]. The purpose of this study is to search for a possible predictive indicator of difficult laryngoscopy from cephalometric roentgenograms of OSAS patients undergoing UPPP.

Subjects and methods

We selected 53 consecutive OSAS patients (49 men and 4 women) undergoing UPPP for the UPPP group and 72 chronic otitis media patients (27 men and 45 women) undergoing tympanoplasty for the control group. Informed consent was received from all patients. All surgery was performed at Kitasato University Hospital and diagnosis of OSAS was made by an otolaryngologist [7]. Difficult laryngoscopy was defined as laryngoscopy attempted unsuccessfully more than three times by anesthesia residents, and Cormack's grade of III or IV confirmed by a staff anesthesiologist [8].

Anatomical analyses from cephalometric roentgenograms were performed in the UPPP group. Standard lateral cephalometric roentgenograms were taken in the neutral position with the mouth closed. The following measurements were made (Fig. 1): (a) tip of upper inci-

Address correspondence to: S. Kato
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sors to temporomandibular joint (cephalometric effective mandibular length, cEML), (b) alveolus immediately behind third molar tooth to lower border of the mandible (cephalometric posterior depth of mandible, cPDM), (c) upper margin of the posterior tubercle of atlas to the occiput (cephalometric atlanto-occipital distance, cAOD), (d) horizontal extension from mandibular angle to cervical vertebrae (cephalometric mandibular angle vertebral level), (e) horizontal extension from hyoid bone to cervical vertebrae (cephalometric hyoid bone vertebral level), (f) vertical distance between mandible and hyoid bone (cephalometric mandibulohyoid distance, cMHD). Finally, the cEML/cPDM ratio was calculated. However, we did not measure these anatomical characteristics in the control tympanoplasty group because X-rays of the neck were not necessary for their treatment.

Data are presented as means ± SD. A two-tailed Mann-Whitney test was used to determine the difference between the two groups except for the data on a nominal scale (the male/female ratio, the incidence of difficult laryngoscopy, and classification by cAOD) which were analyzed by the χ^2 test. A value of $P < 0.05$ was determined as significant.

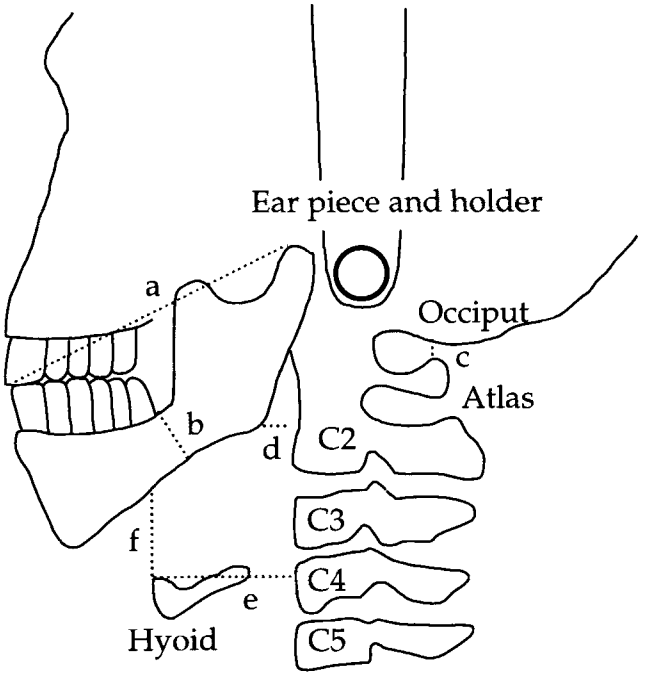

Fig. 1. Measurements from lateral cephalometric roentgenograms. *a*, cephalometric effective mandibular length (cEML); *b*, cephalometric posterior depth of mandible (cPDM); *c* cephalometric atlanto-occipital distance (cAOD); *d*, cephalometric mandibular angle vertebral level; *e*, cephalometric hyoid bone vertebral level; *f*, cephalometric mandibulohyoid distance (cMHD)

Table 1. Demographic data in the UPPP group and the tympanoplasty group

Group	UPPP	Tympanoplasty
n	53	72
Age (years)	44 ± 10	49 ± 12
Male/female	49/4***	27/45
Height (cm)	168.0 ± 7.9	157.5 ± 7.7
Weight (kg)	74.9 ± 15.1*	55.3 ± 8.6
Body mass index	26.4 ± 4.2***	22.2 ± 2.7
Difficult laryngoscopy	10/53**	3/72
(%)	(18.9%)	(4.2%)

UPPP, uvulopalatopharyngoplasty.
Body mass index = weight(kg)/height^2(m^2).
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Table 2. Anatomical measurements in the UPPP group

Group	Difficult laryngoscopy	Nondifficult laryngoscopy
cEML (mm)	103 ± 3	105 ± 5
cPDM (mm)	26 ± 5*	24 ± 3
cAOD (mm)	3 ± 3***	7 ± 3
cMHD (mm)	30 ± 7	31 ± 7
cEML/cPDM ratio	4.0 ± 0.6**	4.5 ± 0.8

cEML, cephalometric effective mandibular length; cPDM, cephalometric posterior depth of mandible; cAOD, cephalometric atlanto-occipital distance; cMHD, cephalometric mandibulohyoid distance.
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Results

The male/female ratio and the body mass index were significantly higher in the UPPP group than the tympanoplasty group (Table 1). The incidence of difficult laryngoscopy was also significantly higher in the UPPP group than in the tympanoplasty group (18.9% *vs* 4.2%, $P < 0.001$). In the UPPP group, all patients in whom direct laryngoscopy was difficult were male.

Anatomical measurements in the UPPP group showed that there were significant differences in the cephalometric posterior depth mandible, cAOD, and cEML/cPDM ratio between the patients in whom direct laryngoscopy was difficult (difficult patients) and the patients in whom direct laryngoscopy was not difficult (nondifficult patients) (Table 2). cAOD in 8 out of 10 difficult patients was within 4 mm (80%), but it was longer than 4 mm in 37 out of 43 nondifficult patients (86%) ($P < 0.001$)(Fig. 2). The cEML/cPDM ratio in 6 out of 10 difficult patients was within 4.0, but in 6 out of 53 nondifficult patients it was within 4.0 ($P < 0.001$) (Fig. 2). There were no significant differences in cEML, cMHD, and cephalometric vertebral level of mandibular angle and hyoid bone between the difficult patients and the nondifficult patients in the UPPP group (Table 2).

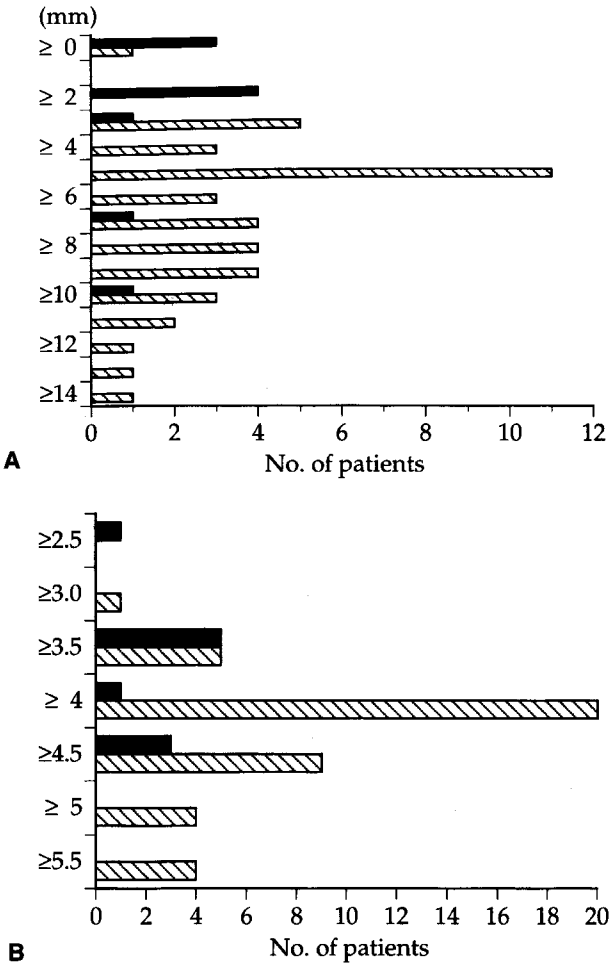

Fig. 2. Cephalometric atlanto-occipital distance (cAOD) (**A**) and ratio of cephalometric effective maxillary length/cephalometric posterior depth of mandible (cEML/cPDM) (**B**) in the patients in whom direct laryngoscopy was difficult (*solid bars*) and the patients in whom direct laryngoscopy was not difficult (*hatched bars*) in the UPPP group

Discussion

Obesity and gender are well-established risk factors in OSAS [9]. Vgontzas et al. reported that sleep apnea was diagnosed in obese men (40%) and women (3%) (mean body mass index, 45.3) [9]. Our results showed a high body mass index and high male/female ratio in the UPPP group which represented the clinical characteristics of OSAS. Because of the higher proportion of males in OSAS, all the difficult patients in the UPPP group were male.

Endotracheal intubation in the UPPP group was significantly more difficult than that in the tympanoplasty group. The incidence of difficult laryngoscopy was approximately 1%–4% in previous reports [10–12], which is similar to that in our tympanoplasty group (4.2%). We demonstrated that the UPPP group had a higher risk (18.9%) of difficult laryngoscopy.

Several anatomical analyses from simple roentgenograms of the head and neck had been reported to predict difficult laryngoscopy [13–15]. However, cephalometric roentgenograms were a screening measurement for OSAS, and there were no reports applying them to analysis of difficult laryngoscopy. Because they were taken under standard conditions, they were more effective in comparisons with many subjects than simple roentgenograms.

Atlanto-occipital distance (AOD) from simple roentgenograms was a major factor in the determination of laryngoscopy which limited the extension of the head on the neck [14]. In our study, cAOD was significantly shorter in the difficult patients than the nondifficult patients in the UPPP group. The median and mode of cAOD of the difficult patients were both 2 mm, and those of the nondifficult patients were 6 mm and 5 mm, respectively. Therefore, 4 mm of cAOD is a useful predictive value to estimate difficult tracheal intubation in the UPPP group.

The EML/PDM ratio from simple roentgenograms was also known to be a factor in the estimation of difficult endotracheal intubation [13]. It was thought that the decrease in the EML/PDM ratio meant a decrease in the posterior depth of the mandible, hindering tongue displacement [13]. In our study, the cEML/cPDM ratio was significantly smaller in the difficult patients than the nondifficult patients. The small cEML/cPDM ratio implies a small oral cavity and relative macroglossia. Although this anatomical abnormality was observed in our study, no previous reports indicated a small cEML/cPDM ratio in OSAS patients [2–6]. The cEML/cPDM ratio was also a useful indicator for estimation of difficult laryngoscopy in the UPPP group; however, measurement of cAOD was easier than that of the cEML/cPDM ratio.

Recently, Chou and Wu [15] reported that the mandibulohyoid distance (MHD), mandibular angle vertebral level, and hyoid bone vertebral level from simple roentgenograms were important factors in estimating difficult laryngoscopy. In our study, however, there were no significant differences in cMHD, cephalometric mandibular angle vertebral levels, and hyoid bone vertebral levels between the difficult patients and the nondifficult patients in the UPPP group. This disagreement with Chou's report may be explained by the difference in the measurement method (simple vs cephalometric roentgenogram) and subjects. Several investigations had reported that cMHD was significantly associated with the degree of OSAS [2,3,5]. Although long cMHD, rostral mandibular angle, and caudal hyoid bone are characteristic of OSAS, they are

not useful predictive factors in the estimation of difficult laryngoscopy in the UPPP group.

In conclusion, the clinical characteristics of OSAS (obesity, narrow middle pharynx, and macroglossia) are also the risk factors which cause difficult endotracheal intubation. Anatomical analysis from cephalometric roentgenograms, cAOD, and the cEML/cPDM ratio were useful indicators in the estimation of difficult laryngoscopy in the UPPP group. However, the measurement of cAOD was easier than that of the cEML/cPDM ratio. Less than 4 mm of cAOD was an effective predictive indicator.

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