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Estimation of nares-to-epiglottis distance for selecting an appropriate nasopharyngeal airway

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Abstract

The nasopharyngeal airway is an important equipment in airway management, a correct placement is crucial for its effectiveness. We measured the nares-to-epiglottis distance (NED) and examined the correlations of the optimal insertion length (NED-1) with patient characteristics and various external facial measurements. We aimed to develop a simple method for estimating the optimal insertion length and to help select an appropriate nasopharyngeal airway.

Two hundred patients of ASA grade I & II aged >20 years undergoing elective surgery under general anesthesia were enrolled. We measured nares-to-ear tragus distance (NTD), nares-to-mandibular angle distance (NMD), philtrum-to-ear tragus distance (PTD), and philtrum-to-mandibular angle distance (PMD). The NED was measured by fiber-optic bronchoscope. All measurements were obtained in centimeters. NED-1 (cm) was defined as the optimal insertion length. The patient's sex, age, body weight, body height, and body mass index were recorded.

The NED-1 significantly correlated with body weight, body height, NTD, NMD, PTD, and PMD. Backward stepwise multiple linear regression analysis yielded the formula for predicting NED-1: $0.331 - 0.018 \times BW + 0.061 \times BH + 1.080 \times NMD - 1.256 \times PMD + 0.697 \times PTD$ ($r = 0.640$, $P < .001$). The regression lines of the optimal insertion length versus PTD showed the best fit to the equality line. The measurements of PTD showed the minimal differences from NED-1 and with the most patients showing <1 cm differences from NED-1.

The optimal insertion depth of nasopharyngeal airway can easily be predicted by the distance from philtrum-to-ear tragus, and a nasopharyngeal airway of an appropriate size can be selected accordingly.

Abbreviations: BH = body height, BW = body weight, NED = nares-to-epiglottis distance, NMD = nares-to-mandibular angle distance, NTD = nares-to-ear tragus distance, PMD = philtrum-to-mandibular angle distance, PTD = philtrum-to-ear tragus distance.

Keywords: external facial measurements, nares-to-epiglottis distance, nasopharyngeal airway

1. Introduction

A nasopharyngeal airway is commonly used for maintaining a patent airway during anesthesia or in an emergency, especially when the oropharyngeal airway is not suitable, such as in patients with an elevated level of consciousness, a light plane of anesthesia, or limitation of mouth opening. An effective nasopharyngeal airway should be placed in an optimal position, with the distal end protruding beyond the soft palate, but should not extend over the epiglottis. Inappropriate placement of the nasopharyngeal airway may cause loss of airway patency and possibly lead to airway obstruction.[1] Accurate prediction of the distance from the nares to epiglottis could help determine the proper insertion depth.

Previously, we introduced a modified lengthened nasopharyngeal airway that was applied for patients receiving nonintubated general anesthesia. [2] This overcomes some defects of the classic nasopharyngeal airway, such as inappropriate length and difficulty in securing it. The insertion depth is crucial for using this modified nasopharyngeal airway. In addition, knowing the distance from the nares to epiglottis is also useful for blind nasotracheal intubation,[3] fiber-optic nasal intubation with a preinserted endotracheal tube,[4] and temperature sensor placement.[5]

In this study, we measured the distance from the nares to epiglottis and examined the relationships of the optimal insertion length (defined as the nares-to-epiglottis distance minus 1 cm) with patient characteristics and various external facial measurements. After data analysis, we aimed to introduce an easy and convenient method to correctly predict the optimal insertion depth of a nasopharyngeal airway, and thereby facilitating the selection of a nasopharyngeal airway of an appropriate size.

2. Methods

Ethical approval for this study (protocol number: 1-104-05-140) was provided by the Institutional Review Board of the Tri-Service General Hospital, Taipei, Taiwan (Chairperson Prof. Mu-Hsian Yu) on December 11, 2015. Written informed consent was obtained from each participant. Patients of ASA grade I & II aged

Editor: Chien-Kun Ting.

This work was supported by grants from the Ministry of Science and Technology, Taiwan (MOST 105-2314-B-016-008).

The authors have no conflicts of interest to disclose.

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Medicine (2019) 98:10(e14832)

Received: 3 December 2018 / Received in final form: 12 February 2019 / Accepted: 14 February 2019

http://dx.doi.org/10.1097/MD.0000000000014832

>20 years undergoing elective surgery under general anesthesia were included. Patients with rhinitis, nasal polyps, bleeding diatheses, or anatomical abnormalities of the face and neck were excluded from this study. All procedures were performed in accordance with the approved guidelines and regulations.

Before anesthesia induction, we performed external facial measurements while the patient's head and neck were in a neutral position. Using a tape-measure, we measured the distance from the lateral border of the nares to the ear tragus (NTD), (2) the distance from the lateral border of the nares to the mandibular angle (NMD), (3) the distance from the philtrum to the ear tragus (PTD), and (4) the distance from the philtrum to mandibular angle (PMD) (Fig. 1). All measurements were obtained in centimeters. After nasal topical anesthesia with lidocaine and conscious sedation with midazolam 0.05 mg/kg plus fentanyl 1 μg/kg, a well-lubricated fiber-optic bronchoscope (PENTAX; Tokyo, Japan) was inserted into the nostril and advanced to the epiglottis. The fiberscope was marked with tape at the nares when the fiberscope's tip exactly touched the epiglottis. The length between the mark and the tip of the fiberscope was measured as the nares-to-epiglottis distance (NED). It has been suggested that the ideal position of the tip of nasopharyngeal airway is 1 cm above the epiglottis.[1] Thus, we defined the optimal insertion length of the nasopharyngeal airway as NED-1 (cm). General anesthesia under tracheal intubation was then carried out as usual. The patient's sex, age, body weight (BW), body height (BH), and body mass index (BMI) were also recorded and calculated.

The difference between males and females was analyzed using an unpaired 2-tailed *t* test. The correlations between the optimal insertion length (NED-1) and patient characteristics and external facial measurements were analyzed using Pearson's correlation coefficient and their statistical significance was evaluated using *t* test. Linear regression analysis was performed to analyze the relationships between the optimal insertion length (NED-1) and the following measurements: age, body weight, body height, BMI, NTD, NMD, PTD, and PMD. A $P < .05$ was considered as significant. Multiple linear regression with a stepwise backward approach was used to estimate equations for the optimal insertion length. All data were analyzed using SigmaPlot version 13.0 for Windows (Systat Software Inc, San Jose, CA)

3. Results

Two hundred patients, 86 males and 114 females, were included in this study. The patient characteristics and all external facial measurements are shown in Table 1. As expected, all of the measurements in females were smaller than those in males, except BMI. The optimal insertion length (NED-1) significantly correlated with BW ($\rho = 0.240$, $P < .001$), BH ($\rho = 0.541$, $P < .001$), NTD ($\rho = 0.312$, $P < .001$), NMD ($\rho = 0.304$, $P < .001$), PTD ($\rho = 0.398$,

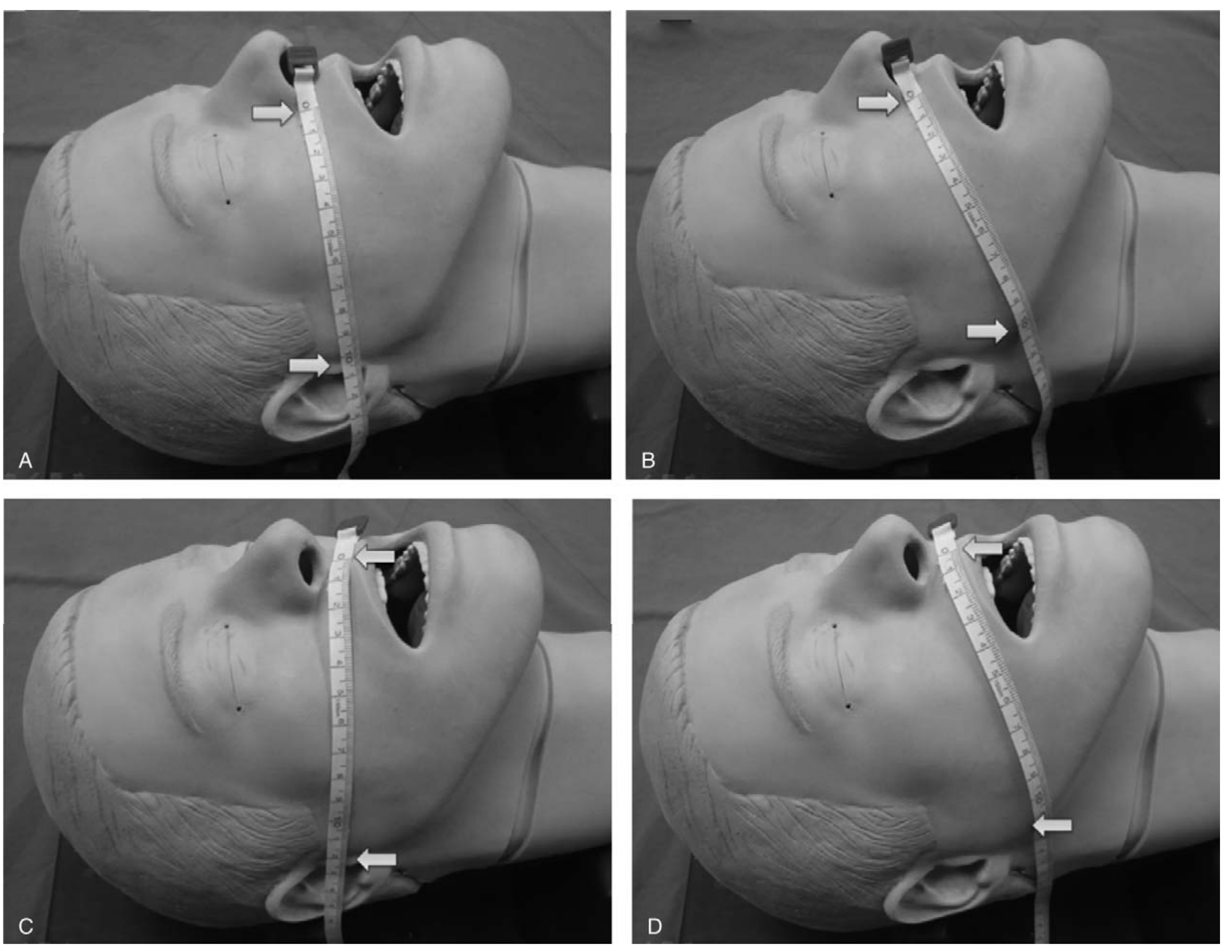

Figure 1. Views of external facial measurements. (A) NTD, the distance from the lateral border of the nares to the ear tragus; (B) NMD, the distance from the lateral border of the nares to the mandibular angle; (C) PTD, the distance from the philtrum to the ear tragus; (D) PMD, the distance from the philtrum to the mandibular angle.

Table 1

Patient characteristics and external facial measurements.

Characteristics	Male	Female	Total
No. of patients	86	114	200
Age, y	37.11 ± 5.8 (20–79)	44.31 ± 2.4* (20–73)	41.21 ± 4.4 (20–79)
BW, kg	71.4 ± 14.4 (50–117)	59.2 ± 11.8* (40–102)	64.4 ± 14.3 (40–117)
BH, cm	171.9 ± 5.9 (160–187)	159.0 ± 6.2* (140–176)	164.4 ± 8.9 (140–187)
BMI	24.2 ± 4.8 (17.4–40.5)	23.5 ± 4.3 (16.9–35.7)	23.8 ± 4.5 (16.9–40.5)
NED, cm	16.8 ± 1.0 (14.7–18.7)	15.6 ± 0.9* (13.5–17.7)	16.1 ± 1.1 (13.5–18.7)
Optimal insertion length (NED-1), cm	15.8 ± 1.0 (13.7–17.7)	14.6 ± 0.9* (12.5–16.7)	15.1 ± 1.1 (12.5–17.7)
NTD, cm	12.8 ± 0.7 (11.5–14.5)	12.2 ± 0.6* (10.8–13.7)	12.5 ± 0.7 (10.8–14.5)
NMD, cm	12.0 ± 0.7 (10.5–13.6)	11.4 ± 0.6* (10.0–13.0)	11.7 ± 0.7 (10.0–13.6)
PTD, cm	15.2 ± 0.7 (13.9–17.0)	14.4 ± 0.7* (12.8–16.3)	14.7 ± 0.8 (12.8–17.0)
PMD, cm	14.0 ± 0.8 (12.2–16.0)	13.3 ± 0.6* (11.8–15.2)	13.6 ± 0.8 (11.8–16.0)

Data represented as mean ± SD (range).

BW = body weight, BH = body height, BMI = body mass index, NED = distance from naris to epiglottis, NTD = distance from lateral border of nasal ala to ear tragus, NMD = distance from lateral border of nasal ala to mandibular angle, PTD = distance from philtrum to ear tragus, PMD = distance from philtrum to mandibular angle.

* $P < .001$, compared with male.

Table 2

The differences between the optimal insertion length (NED-1) and the external facial measurements.

Measured variables	Differences, cm
NTD	2.61 ± 1.10
NMD	3.42 ± 1.11
PTD	0.89 ± 0.68
PMD	1.60 ± 1.03

Data represented as mean ± SD.

NTD = distance from lateral border of nasal ala to ear tragus, NMD = distance from lateral border of nasal ala to mandibular angle, PTD = distance from philtrum to ear tragus, PMD = distance from philtrum to mandibular angle.

$P < .001$), and PMD ($\rho = 0.241$, $P < .001$). The formula derived from the regression line between the optimal insertion length and the BH (highest correlation coefficient) was as follows: NED-1 = 4.054 + 0.067 × BH ($r = 0.541$, $P < .001$). Backward stepwise multiple linear regression analysis yielded the following best-fit formula to predict the optimal insertion length: NED-1 = 0.331 − 0.018 × BW + 0.061 × BH + 1.080 × NMD − 1.256 × PMD + 0.697 × PTD ($r = 0.640$, $P < .001$). Figure 2 shows the linear relationship between the optimal insertion length and various measured parameters. The regression lines of the optimal insertion length versus PTD showed the best fit to the equality line of the scatter chart. The absolute values of differences between the optimal insertion length and the external facial measurements are shown in Table 2. The measurements of PTD

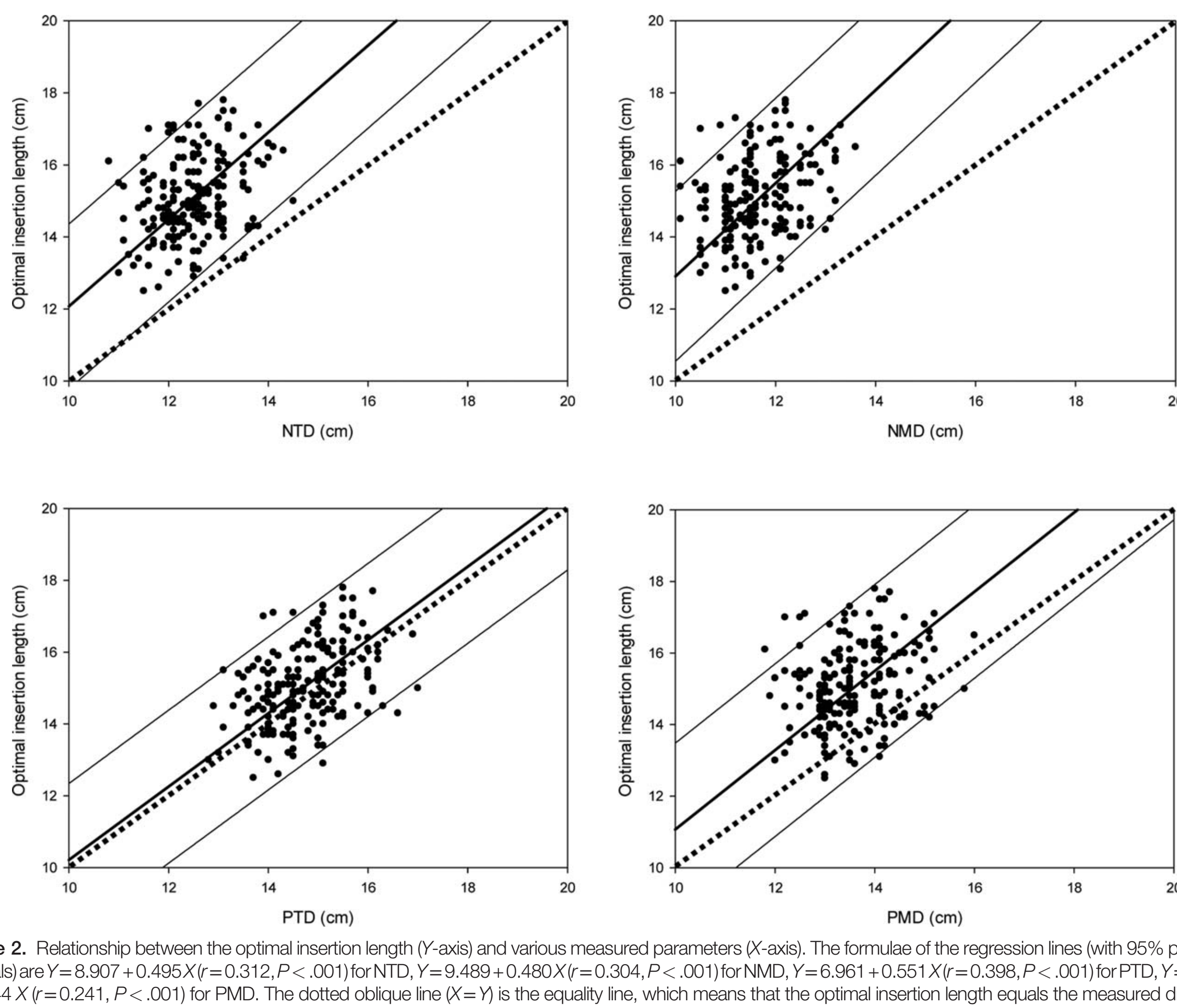

Figure 2. Relationship between the optimal insertion length (Y-axis) and various measured parameters (X-axis). The formulae of the regression lines (with 95% prediction intervals) are $Y = 8.907 + 0.495X$ ($r = 0.312$, $P < .001$) for NTD, $Y = 9.489 + 0.480X$ ($r = 0.304$, $P < .001$) for NMD, $Y = 6.961 + 0.551X$ ($r = 0.398$, $P < .001$) for PTD, $Y = 10.398 + 0.344X$ ($r = 0.241$, $P < .001$) for PMD. The dotted oblique line ($X = Y$) is the equality line, which means that the optimal insertion length equals the measured distances.

Table 3

The distribution of number (%) of the patients which counted by various differences between the optimal insertion length and external facial measurements.

Ranges of difference, cm	NTD	NMD	PTD	PMD
0–1	14 (7.0)	0 (0.0)	120 (60.0)	60 (30.0)
1–2	40 (20.0)	19 (9.5)	65 (37.5)	73 (36.5)
2–3	78 (39.0)	44 (22.0)	13 (6.5)	44 (22.0)
3–4	43 (21.5)	75 (37.5)	2 (1.0)	19 (9.5)
4–5	20 (10.0)	43 (21.5)	0 (0.0)	4 (2.0)
5–6	5 (2.5)	15 (7.5)	0 (0.0)	0 (0.0)
6–7	0 (0.0)	4 (2.0)	0 (0.0)	0 (0.0)

NMD = distance from lateral border of nasal ala to mandibular angle, NTD = distance from lateral border of nasal ala to ear tragus, PMD = distance from philtrum to mandibular angle, PTD = distance from philtrum to ear tragus.

revealed the smallest differences from NED-1. Table 3 shows the distribution of the number of the patients with various differences between the optimal insertion length and the external facial measurements. The measurements of PTD differed from NED-1 by <1 cm for most patients. According to the results of Figure 2 and Tables 2 and 3, the PTD is the best measurement to predict the optimal insertion depth of a nasopharyngeal airway.

4. Discussion

The goal of this study was to find a simple and convenient method for estimating the optimal insertion length of a nasopharyngeal airway, and thereby facilitating the selection of a nasopharyngeal airway of an appropriate size. This study showed that the optimal insertion depth of a nasopharyngeal airway is correlated with BW, BH, and various external facial measurements. Many formulae could be obtained from the associated regression lines. For more accurate prediction, a formula derived by backward stepwise multiple linear regression was also obtained in this study. However, all of these formulae are too complicated to remember, and not convenient for clinical use. The results of this study showed that the PTD was the best measurement for predicting the optimal insertion length of a nasopharyngeal airway.

The nasopharyngeal airway is used to maintain a patent upper airway. It is superior to the oropharyngeal airway in some circumstances such as in patients with an intact gag reflex, light plane of anesthesia, or limitation of mouth opening. It has been reported that the nasopharyngeal airway has been underutilized.[6] The classic nasopharyngeal airway has some defects, such as inappropriate length and difficulty in securing it. The length is more important than diameter in selecting an appropriate nasopharyngeal airway.[6] However, the length of a classic nasopharyngeal airway is fixed for each diameter. When a smaller-sized nasopharyngeal airway is chosen, the tube is usually too short to be properly placed. Fixation is another problem for the classic nasopharyngeal airway; inadvertent aspiration of the nasopharyngeal airway has been reported.[7–9] Accordingly, we previously introduced a modified lengthened nasopharyngeal airway to ameliorate these drawbacks of the classic nasopharyngeal airway.[2] This modified nasopharyngeal airway was successfully applied in patients receiving nonintubated general anesthesia for tympanoplasty [2] and awake craniotomy,[10] and also beneficially used after orthognathic surgery.[11] An optimal predicted insertion length is crucial for using this modified lengthened nasopharyngeal airway.

Regarding the selection of a classic nasopharyngeal airway, it is recommended to use a size 6 (13 cm in length) for females and a size 7 (15 cm in length) for males, but the size should be adjusted according to the patient's height.[6,12] Alternatively, an appropriate classic nasopharyngeal airway can be selected on the basis of its length, which should equal the distance from the nares to ear meatus.[13] These suggestions are not, however, reliable for predicting the optimal insertion depth. Several previous studies have measured the length from the nares to epiglottis for different purposes and derived many formulae from the linear regression analyses between the NED and several external facial measurements. [1,3,4,14,15] All of these prediction formulae are too cumbersome, though for clinical application. In the present study, we not only derived several formulae similar to those in previous reports, but also provided an easy and convenient method, PTD measurement, for predicting the optimal insertion depth of a nasopharyngeal airway. This simple measurement to predict the NED could be also useful in blind nasotracheal intubation, fiber-optic nasal intubation with a preinserted endotracheal tube, and temperature sensor placement.

There are some limitations to this study. First, the results are not applicable to patients with facial deformities. Second, the patients in this study are Chinese. There was no literature to investigate the difference of cephalometric measurements between Chinese and other races. Further similar studies for other races are needed.

5. Conclusions

The optimal insertion length (NED-1) of a nasopharyngeal airway is correlated with BW, BH, NTD, NMD, PTD, and PMD. The length from PTD is a good predictor for estimating the optimal insertion depth of the nasopharyngeal airway; it can also be helpful in selecting a nasopharyngeal airway of an appropriate size.

Author contributions

W-CT contributed to the data collection, data analysis, and manuscript preparation. W-LL contributed to the data collection and analysis. C-HC contributed to all aspects of this manuscript, including conception and design, data analysis and interpretation, and manuscript writing.

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