

# Insertion depth of nasotracheal tubes sized to fit the nostril: an observational study

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## Abstract

**Objective:** Nasotracheal (NT) intubation is commonly applied during head and neck surgery. However, improper tube size and depth may cause complications. In the current study, we investigated whether NT tubes are being appropriately used in terms of size and depth in adult patients.

**Methods:** Nares were sized in 40 patients using standard nasopharyngeal airways (6.0–8.0) before elective surgery under general anesthesia. The largest sized airway that passed easily into the nasopharynx without resistance was considered as a proper size. Using a fiberoptic scope, the distances from the nares to the vocal cords and the nares to the carina were measured. Rates of proper NT tube positioning were calculated with regard to the cuff and distal tip.

**Results:** The most frequent sizes of properly fitted NT tubes were 6.5 and 6.0 in male and female patients, respectively. Positioning of the cuff and distal tip was only appropriate when using a properly sized tube in 26% and 47% of male and female patients, respectively.

**Conclusion:** Care should be taken to determine the insertion depth after placing an NT tube that has been sized to fit the nostril. Moreover, NT tubes of the same diameter may be required in various lengths.

**Trial registration:** Registered at ClinicalTrials.gov; <https://clinicaltrials.gov/ct2/show/NCT02876913>; Registration number NCT02876913

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## Keywords

Airway management, nasopharyngeal airway, nasotracheal intubation, carina, head and neck surgery, nostril, tube size

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## Introduction

Nasotracheal (NT) intubation is commonly performed in patients undergoing head and neck surgeries, such as intraoral, dental, or microlaryngeal procedures or mandibulectomies.<sup>1,2</sup> Nonetheless, the choice of tubes used in clinical practice must be judicious.<sup>2,3</sup> Previous studies have suggested that the proximal cuffs of NT tubes should be placed  $>2$  cm below the vocal cords<sup>4,5</sup> because upward movement (towards the cords) may be damaging or result in unintentional extubation during surgery.<sup>6,7</sup> Various head and neck positions may also alter the relative depth of the proximal cuff.<sup>8</sup> Extension or rotation may lengthen the airway and cause withdrawal of the tube.<sup>9</sup> Moreover, a downwardly displaced distal tip (*i.e.*, tubal shift towards the carina) creates the potential for endobronchial intubation, atelectasis, or hypoxemia.<sup>10</sup> Such displacement is possible during flexion of the neck, the Trendelenburg position, or laparoscopically-induced pneumoperitoneum.<sup>11–13</sup> Consequently, a separation of  $5 \pm 2$  cm between the distal tip and the carina is advised.<sup>12</sup>

An NT tube should be reasonably accommodated by the nostril cavity.<sup>1</sup> Many complications associated with insertion of an oversized NT tube have been reported, including epistaxis, turbinectomy, retropharyngeal dissection, and nasal ala pressure sores or necrosis.<sup>14–16</sup> These complications might be reduced by implementing several strategies, such as warming of

the tube, and use of lubricants or a vasoconstrictor.<sup>2,17</sup> Additionally, such complications may be prevented via proper tube sizing.<sup>18</sup> The diameter of a tube intended for nasal passage is understandably less than that of a tube that is passed orally.<sup>2</sup>

Despite the fundamental importance of these issues, no studies have evaluated NT size and depth concurrently. Furthermore, in our clinical experience, coordinating tube size and length to limit potential complications (*e.g.*, unintentional extubation or epistaxis) has been difficult. The uniquely preformed curvatures of standard NT tubes and the complexities of intranasal structures might be at odds, resulting in an imbalance in the proportionate relationship between the sizes and lengths of these tubes.<sup>2,19</sup>

This prospective, observational study was performed to determine whether NT tubes are used properly in terms of size and insertion depth in adult patients. We investigated whether the tube depth was appropriate regarding cuff and distal tip positions when a properly fitted NT tube was selected according to nostril size.

## Materials and methods

### Patients

This study was approved by the Severance Hospital institutional review board (protocol number: 4-2016-0504) and registered at ClinicalTrial.gov (NCT02876913). We enrolled 40 patients of class I or II

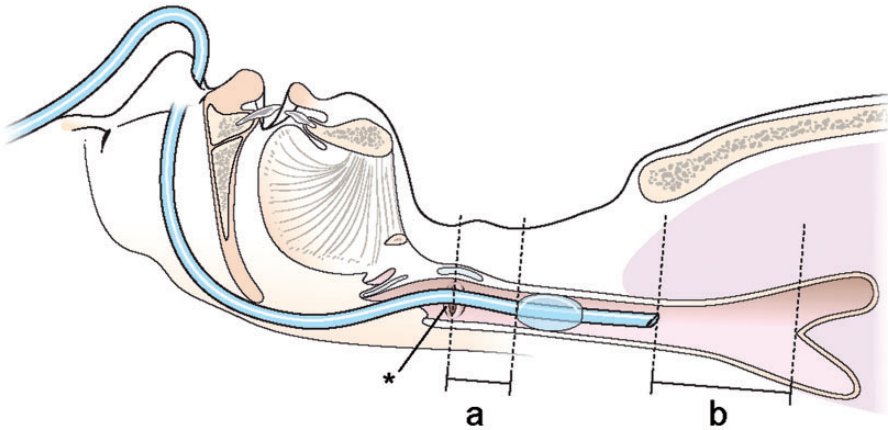
American Society of Anesthesiologists physical status. All of the patients were scheduled for elective oral and maxillofacial surgery requiring NT intubation between August 2016 and June 2017. All of the patients provided written informed consent. Exclusion criteria were a history of difficult intubation, modified Mallampati score > 3, mouth opening < 2 cm, facial anomaly, unstable teeth, and nasal disease.

### Measurements

Each patient was placed on the operating table with their head and neck in a neutral position. We measured straight distances from the lateral border of the nares to the tragus of the ear (NE) and to the angle of the mandible (NM) using a protractor and tape measure. Before induction, the patient identified which nostril they felt the most comfortable breathing through.<sup>20</sup> Anesthesia was induced with propofol (Fresofol 1% MCT, 2 mg/kg; Fresenius Kabi Austria GmbH, Graz, Austria), rocuronium (Rocumeron, 0.8 mg/kg; Ilsung Pharmaceuticals Co., Ltd., Seoul, Korea), and remifentanyl (Ultian, 0.5–1.0 µg/kg; Hanlim Pharm. Co., Ltd., Seoul, Korea). After mask ventilation (2.0%–2.5% sevoflurane in 100% oxygen) that was sufficient to ensure muscle relaxation, a nasopharyngeal airway (PVC airway, 6.0–8.0; SunMed, Grand Rapids, MI, USA) that was well lubricated with jelly was vertically inserted into the predetermined nostril. If a size 6.0 nasopharyngeal airway could not be inserted without more than mild resistance, insertion was attempted on the other side. The largest nasopharyngeal airway that could be easily passed into the nasopharynx without resistance was considered the proper size. Friction that was encountered between the nasopharyngeal airway and intranasal structures was considered mild resistance. Moderate resistance was defined as

intranasal encroachment and abrasion during airway insertion, with the potential for bleeding.<sup>3</sup> The largest tube that showed mild resistance upon insertion was considered a tight fit. A very tight fit was calculated by adding 0.5 mm to the size of the tightly fitting airway. If more than mild resistance was met when passing a size 6.0 airway into the nasopharynx, no attempt was made to use a larger airway because of the risk of bleeding, turbinectomy, or submucosal dissection.<sup>3,18</sup> The outer diameter of a properly sized nasopharyngeal airway corresponded with the inner nostril diameter. In airways with inner diameter sizes of 6.0, 6.5, 7.0, 7.5, and 8.0 mm, the respective outer diameters were 8.0, 8.7, 9.3, 10.0, and 10.7 mm. The outer diameter of an NT tube (Mallinckrodt TaperGuard cuff; Medtronic, Minneapolis, MN, USA) marginally exceeded that of a nasopharyngeal airway, with a difference of only 0.2 mm.

Upon removing the nasopharyngeal airway, mask ventilation (2.0%–2.5% sevoflurane in 100% oxygen) was reintroduced for 1 minute. Following facial mask removal, a fiberoptic bronchoscope (Olympus LF-P; Olympus Corp, Tokyo, Japan) was inserted through the nostril. The distances from the nares to the carina and from the nares to the vocal cords were measured. The scope was inserted until its distal end just made contact with the carina, while maintaining the patient's neck in a neutral position. Tape was applied at the nares to mark the bronchoscopic location, and it was withdrawn until the distal tip was positioned precisely between the vocal cords. Tape was applied again, and the distances from tape markings to the distal end of the fiberoptic bronchoscope were measured with a ruler. Laryngoscopic NT intubation was performed using a tube that had been warmed and softened by warm water, and anesthesia was maintained via sevoflurane (0.8–1.0 age-adjusted minimal alveolar



**Figure 1.** Ideal depth of nasotracheal tube placement with (a) the cuff 2 cm below the vocal cords and (b) the distal tip  $5 \pm 2$  cm from the carina. \*Vocal cords

concentration in 50% O<sub>2</sub>/air) and remifentanyl (0.05–0.15 µg/kg/minute).<sup>17</sup>

Once the tube was fixed at the start of curvature (6.0, 25 cm; 6.5, 26 cm; 7.0, 27 cm; 7.5, 28 cm; 8.0, 29 cm), proper positioning of the NT tube required that the cuff was 2 cm below the vocal cords,<sup>4</sup> and the distal tip was  $5 \pm 2$  cm from the carina.<sup>12</sup> Both stipulations were mandatory (Figure 1). Additionally, the distance between the nares and the distal tip of the tube (relative to the carina) minus 5 cm was considered ideal. The primary outcome was the rate of proper NT tube positioning with regard to the cuff and distal tip.

### Statistical analysis

Continuous variables are expressed as mean (standard deviation) or median (interquartile range) and categorical variables as numerical values (percentile). Patients' characteristics and operative data were compared using the unpaired *t*-test, Mann–Whitney U-test,  $\chi^2$  test, or Fisher's exact test as appropriate. Clinically related variables were evaluated by correlation analysis. All statistical tests were two-tailed, with significance set at  $p < 0.05$ .

Analyses were performed using IBM SPSS Statistics for Windows, version 23 (IBM Corp., Armonk, NY, USA) and R software (version 3.4.3; R Foundation for Statistical Computing, www.r-project.org).

### Results

All 40 patients fully completed the study. There were 20 men and 20 women, aged 20 to 70 years. In all cases, the nostrils that were intubated were preferentially selected by the patients, and the chosen nostril did not need to be abandoned for any reason. The types of oral and maxillofacial surgeries performed included enucleation of a cyst, surgical tooth extraction, and excision of a mandibular mass.

Patients' characteristics and recorded data are shown in Table 1. Weight, height, distance from the nares to the vocal cords, and distance from the nares to the carina were greater in male patients than in female patients (all  $p < 0.01$ ). Age, NM, and NE did not differ significantly by sex. The most frequent calibers of properly sized tubes were 6.5 in male patients and 6.0 in female patients. A size 6.0 nasopharyngeal

**Table 1.** Baseline characteristics and values measured by fiberoptic bronchoscopy and nasopharyngeal airways.

	Male patients (n = 20)	Female patients (n = 20)	p value
Age (years)	42 ± 14	41 ± 13	0.855
Height (cm)	172.4 ± 5.8	162.3 ± 5.5	<0.001
Weight (kg)	69.7 ± 12.8	58.6 ± 10.2	0.004
NV distance (cm)	18.6 ± 1.4	16.7 ± 1.2	<0.001
NC distance (cm)	31.4 (30.1–32.3)	28.7 (27.9–29.7)	<0.001
NE distance (cm)	10.8 ± 0.8	10.4 ± 1.4	0.366
NM distance (cm)	9.9 (9.0–10.2)	9.2 (8.8–10.0)	0.515
Ideal distance between the nares and the distal tip of tube, relative to the carina	26.4 (25.1–27.4)	23.7 (22.9–24.7)	<0.001
Nostril side (left/right)	10/10	8/12	0.523
Easily passed nasopharyngeal airway size			
6.0	2	7	0.177
6.5	8	5	
7.0	7	3	
7.5	0	1	
8.0	2	1	

Values are expressed as mean (standard deviation), median (interquartile range), or patient number. NV = nares to the vocal cords; NC = nares to the carina; NE = lateral border of the nares to the tragus of the ear; NM = lateral border of the nares to the angle of the mandible. The distance from the nares to the distal tip of the tube minus 5 cm was considered the ideal measurement relative to the carina.

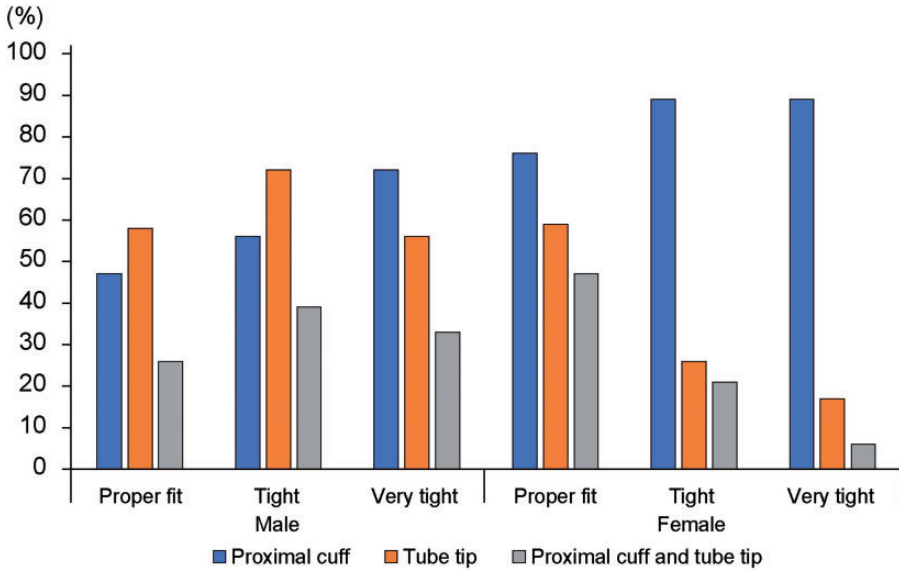
airway was considered tight in one male and in three female patients.

Appropriate NT tube depths were recorded in 26% male and 47% female patients according to proper tube sizes and stipulated cuff/distal tip locations (Figure 2). When the cuff and distal tip position were considered, the appropriate rates were highest with tight fitting NT tubes in male patients and properly fitting NT tubes in female patients, although notably, both rates were < 50%. Based on the distal tip position, in male patients, the appropriate depth was more likely to be achieved with a tight fitting NT tube than with a properly fitting NT tube. However, in female patients, as the tube size became tighter, the position of the distal tip became closer to the carina, resulting in a higher inappropriate rate (approximately 85%). Based primarily on the cuff position,

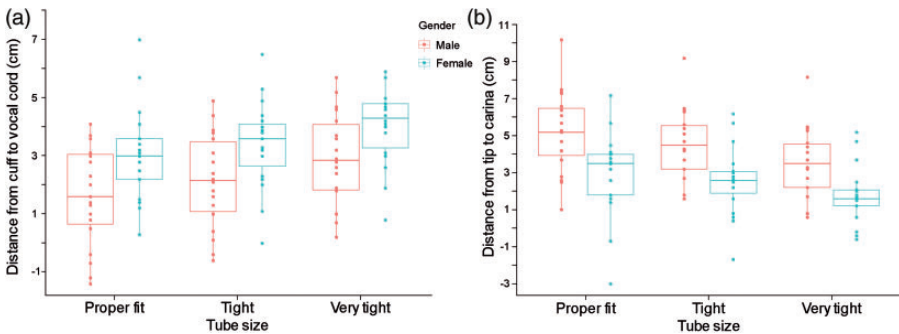
a tight NT tube was most appropriate in female patients, whereas in male patients, a very tight size was most appropriate.

Increased tube caliber was associated with the distal tip advancing closer to the carina and the cuff being further from the vocal cords (Figure 3). In male patients, cuff positions of properly sized NT tubes tended to fall short. The cuff positions encroached on the vocal cords in > 50% of patients, thus qualifying as inappropriate. In contrast, properly sized NT tubes were often associated with cuff positions that were too long in female patients, and this limited the distance between the distal tip and the carina. Only 59% of female patients qualified as appropriately positioned.

Correlation analysis showed a Pearson coefficient of -0.136 associated with the relationship between proper nasopharyngeal airway size and height. The relationship



**Figure 2.** Rates of appropriate nasotracheal tube positioning based on a tube size accommodated by the nostril of the patient.



**Figure 3.** Box plots showing the distances from (a) the cuff to the vocal cords and (b) the distal tip to the carina based on the tube size accommodated by the nostril of the patient.

between the ideal distance from the nares to the distal tip of the tube and height showed a Pearson coefficient of 0.584.

**Discussion**

To the best of our knowledge, this prospective, observational study is the first to investigate appropriate use of NT tubes based on

size and insertion depth. These results suggest that using an NT tube that is properly sized for a particular patient will not ensure appropriate placement, as defined by cuff and distal tip positions. In the present study, the cuff position was inappropriate in 24% to 53% of patients for whom properly sized NT tubes were selected. This observed rate exceeded our expectations,



although we have frequently encountered cuffs caught in the vocal cords when extending a patient's head and neck. In clinical practice, we often use NT tubes that are tight or very tight, as a safeguard against accidental extubation. Moreover, some clinicians insert NT tubes beyond recommended markings to prevent cord encroachment by the proximal cuff.<sup>8,21</sup> Such anticipatory behavior may skew the incidence of improperly positioned proximal cuffs. Nevertheless, NT tubes should be fixed at the first sign of curvature or at the manufacturer's designated mark because of the risk of nasal ala pressure sores.<sup>22,23</sup> Furthermore, proper sizing of NT tubes—in conjunction with nostril cavities—helps reduce the risk of unnecessary bleeding.<sup>1,18</sup> Therefore, we investigated whether properly sized NT tubes can reach appropriate depths relative to the proximal cuff. Our findings indicated that the proximal cuff was positioned too close to the vocal cords, which created the potential for cord damage or accidental extubation, when a properly sized NT tube was fixed as intended.

Larger sized tubes incorporate a longer distance from curvature to the proximal cuff compared with smaller sized counterparts. Therefore, the distance from the vocal cords to the proximal cuff may be greater in larger sized tubes. In the current study, the rate of appropriate proximal cuff positioning increased proportionally as tube size increased. However, as tube size increased, the distal tip also moved closer to the carina, which increased the risk of endobronchial intubation and rendered tube placement inappropriate.<sup>5,12</sup> When we chose a larger sized NT tube than the patient's nostril size to ensure an appropriate proximal cuff position of the NT tube, the distal tip position was inappropriate in approximately 85% of female patients. Male patients were similarly affected, although not to the same extent because

the distance from the nares to the carina is longer in male patients than in female patients, increasing the margin of safety.<sup>24</sup>

Previous NT tube studies that used sizes of 6.0 to 6.5 for female patients and 7.0 for male patients did not provide a basis for size selection.<sup>25,26</sup> Anesthesiologists are usually guided by sex and height when choosing NT tubes, taking into consideration that a larger sized tube has a longer tube length. In a previous study, the distance from the nares to the vocal cords was significantly correlated with the patient's height.<sup>27</sup> Similarly, in the current study, there was a positive correlation between the ideal distance from the nares to the distal tip of the tube and the patient's height. NT tube size is positively associated with NT tube length because of product design. Therefore, if an NT tube is selected to ensure proper tube position based on the patient's height, the diameter of the NT tube can be too small or too large for the patient's nostril. Consequently, tubes of the same size should be made available in various lengths so that nostril size and patient's height can be accommodated. A previous study showed that NT intubation at 26 cm and 28 cm in female and male patients, respectively, measured at the nares, enabled adequate placement in most adult patients.<sup>28</sup> While these data were generated indirectly using chest radiographs, our determinations were based on direct measurements relative to the carina obtained via fiberoptic bronchoscopy (ideal depth: 26.5 ± 2 cm in male patients; 23.7 ± 2.0 cm in female patients). Therefore, a new perspective on the design and production of NT tubes that offers variability in length and caliber is required.

There are several limitations of our study as follows. First, our study had a small sample size. However, post-hoc power analysis showed power values > 0.9 for the rates of appropriate NT tube positions in male and female patients when we assumed an

inappropriate position rate of 0% to 10%.<sup>29,30</sup> Therefore, our sample size appears to have been sufficient to support the primary endpoint of the current study. Additionally, there was subjectivity involved in gauging the ease of, or resistance to, passage of the NT tube. Pressure may be applied to increase nasal cavity resistance, and the internal nasal contours are not uniform with regard to geometric shapes (*i.e.*, simple circles or rectangles). In an effort to maximize the objectivity of our data within the limitations of the study, the same experienced anesthesiologist assessed nasopharyngeal airway resistance and performed the actual NT intubation procedures in all patients.<sup>3,31</sup>

The rate of inappropriate placement is high if the nostril diameter serves as the determinant of a properly sized NT tube. Therefore, care should be taken to determine tube depth when choosing an NT tube that is sized to fit the nostril. Further investigation of a formula for predicting the appropriate fixation depth is also warranted. NT tubes of the same diameter may need to be made available in various lengths to accommodate the nostril size and airway length.

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### Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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