Studies on the Correct Length of Nasopharyngeal Airways in Adults

A Literature Review

Catharina Scheuermann-Poley, MD; André Lieber, MD*

ABSTRACT

The use of a nasopharyngeal airway (NPA) as an adjunct airway device can be critically important in emergency medicine. When placed correctly, the device can prevent upper airway obstruction. The goal of our review was to learn whether there is scientific evidence about the correct length and the insertion depth, and also possible facial landmarks, that can predict the appropriate length of the NPA. There has been no real consensus on how to measure the appropriate tube length for the NPA. Several studies have been able to demonstrate correlations between facial landmarks and body dimensions; however, we did not find any scientific evidence on this matter. The reviewed studies do not indicate evidence to support current recommended guidelines. This could potentially lead to both military and civilian emergency training programs not having the most accurate scientific information for training on anatomic structures and also not having a better overall understanding of intraoral dimensions. Emergency personnel should be taught validated scientific knowledge of NPAs so as to quickly determine the correct tube length and how to use anatomic correlations. This might require further studies on the correlations and perhaps radiographic measurements. A further approach includes adjusting the tube to its correct length according to the sufficient assessment and management of the airway problem.

Keywords: *airway; nasopharyngeal; tubes; emergency; trauma*

Introduction

The NPA is an important airway management device used in military and civilian first-line emergency medicine and in routine anesthesiology. This simple airway adjunct can prevent upper airway obstruction caused by the tongue to maintain a clear airway and facilitate nasotracheal suctioning.[1,2] The correct use, placement, and length of the tube are crucial for its effective application.

To maintain a stable airway, the NPA is commonly used especially when the oropharyngeal airway is not suitable because of oral trauma (e.g., bleeding, swelling, disruption of the roof of the mouth) or facial trauma (e.g., Le Fort fractures) or for a surgical procedure requiring access to the mouth or tongue. Another reason might be with patients who cannot tolerate an oropharyngeal airway (e.g., a patient with an elevated level of consciousness, maintained gag reflex, or limited mouth opening).[3]

Multiple advantages are associated with the use of NPA tubes. They can quickly provide airway proficiency thought to be better tolerated than oral airways or oral endotracheal tube intubation,[4] and the nasal placement of an NPA tube seems to minimize gagging. It can be applied without the use of any further device, and the nasal route is also preferred during fiberoptic intubation.[5] Despite these advantages, however, the NPA appears to be used less frequently than needed, possibly because of reports of intracranial misplacement, specifically in basal skull fractures.[2] There have been at least two case-study reports from the US military of intracranial placement of NPAs because of craniofacial trauma.[6,7]

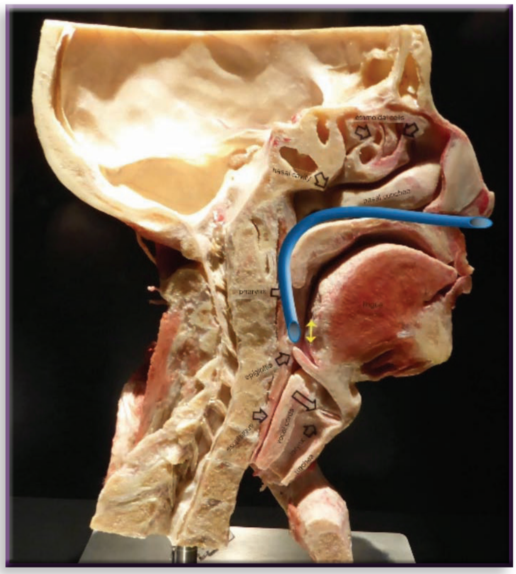
Early NPA tubes were plain, uncuffed rubber tubes; these have been replaced with tubes made of better materials (e.g., latex, soft polyvinyl chloride, silicone), while potential displacement into the pharynx is prevented by a flange at the proximal end.[8] The correct and effective NPA tube has an optimal position with the proximal end fully inserted up to the flange at the nostril opening[9] and the distal end protruding beyond the pharyngeal edge of the soft palate, not extending over the epiglottis.[4,8,10] Some studies and guidelines have established that the best position for the distal NPA tip is 1cm above the epiglottis[2,3,8,9] (Figure 1). Malpositioning of the NPA tube may cause oxygen deprivation, with such serious consequences as hypoxia, hypercapnia, gastric acid reflux, aspiration, neurological impairment, or death.[2,3,8]

Several studies have examined the correlation between the NPA and various body measures, such as height, weight, and arm length, as well as correlating the NPA to other external body measurements.[6] An accurate prediction of the optimal length and insertion depth of the NPA tube is critical in providing an effective adjunct for airway management. Because it is performed without visualization of nasopharyngeal structures, when NPA insertion is required, it is essential to have certain landmarks that predetermine the optimal length of the NPA, especially in emergency situations.

Frequently taught methods of sizing an NPA are based on the width of the patient's nostril or little finger. Magnetic resonance imaging (MRI) data demonstrate that these methods are

*Correspondence to cathipoley@web.de
Major Scheuermann-Poley and **Colonel Lieber** are affiliated with the Department of Orthopedic, Septic and Reconstructive, and Thoracic Surgery, Military Hospital Berlin, Germany.

FIGURE 1 *Sagittal cross section of the head with the suggested position of a nasopharyngeal airway (NPA) tube. The NPA tube must pass through the nasopharyngeal space and go beyond the base of the tongue, but not touch the epiglottis.*



blue = NPA tube, yellow = tolerance range before reaching the tip of the epiglottis.

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inaccurate.[2] Studies indicate the ideal NPA length, measured by nasal endoscopy, correlates with the patient's height, making it easier to estimate the correct NPA length in the clinical setting.[2] Guidelines for measuring the correct length of NPA tubes are very different, nationally and internationally. It is also important that users of NPA tubes recognize, based on the tube manufacturer, that the length is often related to the external diameter.

The goal of our MEDLINE search was to learn (1) whether there are studies providing valid guideline measurements to determine the optimal NPA tube length and (2) whether the often cited guidelines between the tube length and nose-tip-to-earlobe distance are correct.

Methods

A MEDLINE search with the keywords "airway," "nasopharyngeal," "tubes," "emergency," and "trauma" was conducted. Sixteen relevant sources were found, which have been included and cited in this article. The MEDLINE search was conducted between March 15, 2020, and July 29, 2020. Inclusion articles ranged in publication dates from 1990 to 2019. All articles were reviewed for their relevance to meet the inclusion criteria as related to nasopharyngeal and NPA use in adults.

Results

To provide us with answers to our two original questions, we found it helpful to divide the reviewed studies into three groups: (1) studies specifically referencing the nares-to-earlobe distance, to provide a clinically acceptable correct distal NPA placement; (2) studies relating the nares-to-epiglottis distance to anatomic landmarks; and (3) studies relating the nares-to-vocal cords distance to anatomic landmarks.

Studies That Specifically Referenced the Nares-to-Earlobe Distance

There were no references in any of the found studies that were related to the nares-to-earlobe distance.

Studies That Specifically Referenced Nares-to-Epiglottis Distance to Anatomic Landmarks

Hwang et al.[1] in 1990 were the first to evaluate the nares-to-epiglottis distance as related to body height in Chinese adults. They used uncuffed 6.0mm endotracheal tubes under direct laryngoscopic vision. Their study included 30 males and 43 females. Their nares-to-epiglottis distance findings (± standard deviation [SD]) were 16.03 ± 1.04cm for males and 14.97 ± 0.95cm in females, with a p value of <.001 and r = 0.41. What they also found was a statistically significant relation between the nares-to-epiglottis distance and the distance from the nose tip-to-mandibular angle. Their statistical findings indicated a correlation between these two references of $p < .004$ and r = 0.324.[1] See Table 1 for their correlation findings relating height to nares-to-epiglottis distance and also comparing nares-to-epiglottis distance to nose-tip-to-mandibular angle.

TABLE 1 *Overview of Studies Regarding Nares-to-Epiglottis Distance and the Extracted Correlations to Anatomic Adult Landmarks*

Nares-to-Epiglottis Distance Related to:	Total Number of Studies	n =	Number of Correlations
Height	4[1,3,8,11]	73 (Hwang et al.[1])	4[1,3,8,11]
		200 (Tseng et al.[3])	
		120 (Stoneham[8])	
		50 (Vamadevan et al.[11])	
Body weight	1[3]	200 (Tseng et al.[3])	1[3]
Nose tip-to-mandibular angle distance	2[1,8]	73 (Hwang et al.[1])	1[1]
		120 (Stoneham[8])	[8]
Nose tip-to-ear tragus distance	8	120 (Stoneham[8])	8
Nares-to-ear tragus distance	1[3]	200 (Tseng et al.[3])	1[3]
Nares-to-mandibular angle distance	1[3]	200 (Tseng et al.[3])	1[3]
Philtrum-to-mandibular angle distance	1[3]	200 (Tseng et al.[3])	1[3]
Philtrum-to-ear tragus distance	1[3]	200 (Tseng et al.[3])	1[3]
Nose tip-to-thyromental distance	1[8]	120 (Stoneham[8])	8

Stoneham[8] published his NPA study in 1993. With prior knowledge of his patients' heights, he performed his measurements via fiberoptic laryngoscope, comparing height and also three facial landmarks to the nares-to-epiglottis distance. This study included 120 patients. The average male nares-to-epiglottis distance was 15.9 ± 1.2cm. The measured female nares-to-epiglottis distance was 14.0 ± 1.1cm. In this study, 60% of NPAs were placed distal to the epiglottis, and 13% were positioned in the vallecula.[8] Table 1 lists his findings, based on regression analysis, in correlating nares-to-epiglottis distance compared to height and three facial landmarks.

Tseng et al.[3] in 2019 evaluated the nares-to-epiglottis distance with the intention of examining the correlation of the optimal NPA insertion length (1cm above the epiglottis, i.e., nares-to-epiglottis distance –1cm) with various external facial measures. Their goal was to estimate the optimal tube length by clinically testing possible correlations to six variables. Measurements were completed using a fiberoptic bronchoscope. The philtrum-to-ear tragus distance showed the least difference from nares-to-epiglottis distance –1cm. The authors concluded that the optimal length and insertion depth of the NPA tube could be predicted by the philtrum-to-ear tragus distance.[3] Table 1 lists their variables and the variable correlations to nares-to-epiglottis distance.

A study conducted by Vamadevan et al.[11] in 2008 evaluated the relation of the NPA length to body height in 50 patients undergoing surgery with nasal intubation without visual optimization. Upon withdrawing the endotracheal tubes, the authors checked the tube withdrawal to compare it to the distal placement of an NPA tube. They found that to maintain good ventilation with NPA placement, male patients had a mean distance of 14cm and females, of 12.4cm. There was a correlation between patient height and NPA positioning performance,[11] as noted in Table 1.

Studies That Specifically Referenced Nares-to-Vocal Cords Distance to Anatomic Landmarks

With the intent to measure the nares-to-vocal cords distance, compared with six external body meaurements, Sareen et al.[12] used fiberoptic nasal intubation in their 2015 study. This study included 50 males and 50 females. The nares-to-vocal cords distances were a mean of 18.5 ± 1.5cm in males and 15.9 ± 1.1cm in females. When combining both gender groups, the authors were able to correlate three of the six anatomic landmarks to the nares-to-vocal cords distance.[12] Table 2 reflects their findings.

TABLE 2 *Overview of Studies Referencing Nares-to-Vocal Cords Distance to Anatomic Landmarks and the Extracted Correlations to Anatomic Adult Landmarks*

Nares-to-Vocal Cords Distance Related to:	Total Number of Studies	n =	Number of Correlations
Height	4[5,10,12,13]	95 (Han et al.[5])	3[5,12,13]
		100 (Sareen et al.[12])	
		26 (Watanabe et al.[10])	0[10]
		54 (Kawamura et al.[13])	
Sternal length	1[12]	100 (Sareen et al.[12])	1[12]
Arm span	1[12]	100 (Sareen et al.[12])	1[12]
Nares-to-ear tragus distance	2[5,12]	95 (Han et al.[5])	1[5]
		100 (Sareen et al.[12])	0[12]
Nares-to-mandibular angle	1[12]	100 (Sareen et al.[12])	0[12]
Nose tip-to-mandibular angle	1[5]	95 (Han et al.[5])	0[5]
Nares-to-thyromental distance	1[12]	100 (Sareen et al.[12])	0[12]
Body weight	1[5]	95 (Han et al.[5])	0[5]

Han et al.[5] in 2005 fiberoptically examined the distance between the nares and the vocal cords, then compared this distance to two external facial measurements in 50 male and 45 female patients. Age, body weight, and height of all patients were recorded. The nares-to-vocal cords distance measured 18.3 ± 0.8cm in males and 16.3 ± 0.7cm in females. A statistically significant correlation to body height was determined, consistent with all other studies on the subect. These findings also indicated a statistically significant correlation between the nares-to-vocal cords and the nares-to-ear tragus distances. The correlations of Han et al.[5] are included in Table 2.

Watanabe et al.[10] examined the optimal length of the NPA by measuring three distances according to their classification of clinical importance. All 26 of their patients were under general anesthesia for elective surgery. Distance A, the distance allowing the release of airway obstruction, was 12.73 ± 0.85cm in males and 11.70 ± 0.75cm in females. Distance B, the disance to provide the most effective ventilation, was 14.55 ± 0.96cm in males and 13.93 ± 1.12cm in females. Distance C, the nares-to-arytenoid cartilage distance, was 18.84 ± 0.90cm in males and 17.40 ± 0.97cm in females. The authors concluded that most commercially provided NPAs are too short; they found distance B to be approximately 2cm longer than distance A, making it necessary to advance the NPA about 2cm farther to provide the most effective ventilation in airway-obstructed patients. Finding no correlation between height and weight, they concluded that using external body parameters to predict optimal length of the NPA tube is difficult.[10] Their finding of no correlation to body height is presented in Table 2.

Kawamura et al.[13] in 2003 measured the length of the nares-to-vocal cords distance by fiberoptic laryngoscope using NPA tubes in 54 patients. Their study showed that the distance of the nares to the vocal cords was dependent on patient gender and did correlate with body height. The measured length in males was 20.2 ± 1.0cm and in females, 17.3 ± 1.1cm.[13] Table 2 provides their correlation findings.

Discussion

The goal of our literature search was to discover (1) whether there are study references that can provide valid guideline measurements to determine the optimal NPA tube length in adults, and (2) whether the often-cited guidelines recommending the measurement of tube length to the nose-tip-to-earlobe distance are correct. None of the articles provided a clear definition of the differentiation between nose-tip and nares. However, what must be recognized is that in many patients, based on their facial features, there is potentially a difference of a few millimeters in these two starting reference points.

The articles we reviewed had a total of 12 variables—external body measurements—correlated to one or both of the following: nares-to-epiglottis distance and/or nares-to-vocal cords distance. Tables 1 and 2 list these variables and the studies that included each of these. Overall, the study designs, their correlated distances, and the different measurements of the included studies were very heterogeneous. Many of the listed results indicate a strong correlation between the patients' height and both the nares-to-epiglottis distance and the nares-to-vocal cords distance.[1-3,5,8,11-13] Therefore, a patient's height might be one of the most important variables in choosing the optimal tube length.

The current and most common method to estimate the correct length of an NPA tube is to measure the distance between the nose tip and earlobe or to compare the tube diameter to the patient's nostril or little finger. However, none of the included study findings demonstrated these specific calculations. Any relation between the little finger or nostril and NPA tube sizing was ruled out by Roberts and Porter.[14] Therefore, the currently taught methods of sizing NPAs are possibly incorrect.[2]

Considering both US national and international accepted protocols, the two most-followed professional guidelines in the use of NPA tubes are those provided by the Tactical Combat Casualty Care (TCCC) and the Advanced Cardiac Life Support (ACLS) guidelines. It is important to note that both military and civilian use of the NPA is of critical life-saving value.

TCCC is the responsibility of the US Department of Defense. These are evidence-based guidelines and considered to be best-practice guidelines specifically customized for the battlefield. First published in 1996, they are typically updated annually. These guidelines identify three phases: (1) Care Under Fire, (2) Tactical Field Care, and (3) Tactical Evacuation. The use of NPA tubes is recognized under the Airway Management section of the TCCC guidelines in phases 2 and 3. The online training video specifies measuring the NPA length from the tip of the nose to the bottom of the ear.[15]

The ACLS online homepage provides information on positioning both oropharyngeal airway and NPA tubes. To determine the correct NPA tube length according to ACLS statements, the nose tip-to-earlobe distance is measured. The diameter of the NPA should be a little smaller than the diameter of the nostril.[9]

The articles we reviewed had an equal number of studies that focused on the nares-to-vocal cords distance and the nares-to-epiglottis distance. The data indicated that the nares-to-vocal cords and nares-to-epiglottis distances are correlated with external body measurements, such as body height. Also, other distances between certain facial landmarks could be useful to determine the correct tube length, such as the nose tip-to-mandible distance and the nose tip-to-ear tragus distance.

Patient gender must also be considered, as well as the fact that many of the studies were conducted among Asian and Indian populations. Because of ethnic variations, facial landmarks may differ. Asian patients usually have a more bulbous nose, with the lack of a defined nasal tip compared with Caucasian noses.[10] Therefore, when studies used the lateral border of the nares as a reference point, as opposed to the nose tip, it becomes more difficult to compare the exact length of certain facial landmark distances.

The referenced distances from the nares-to-epiglottis and nares-to-vocal cords varied widely in our reviewed studies. This may be because of gender and ethnicity, but it eliminates a general "one-size-fits-all" perception of the optimal NPA tube length. According to Stoneham,[8] one solution would be to manufacture standardized NPA tubes of the same length with different diameters and then apply the correct length by changing the safety pin or adjusting the flange.[8] Newer tubes provide an adjustable flange ring. However, in an emergency situation, it might be easier to choose from a variety of different tube lengths and then insert the tube up to the flange instead of dealing with adjustable parts. Also, NPA tubes with an adjustable flange are more expensive, which also needs to be taken into consideration.

According to Sareen et al.,[12] the ability of the NPA to maintain a patent airway is dependent on the internal diameter of the tube and the correct distal positioning. However, it is our belief, and that of many study authors, that the length of the tube is more important than the diameter.[2,3,8,9] Stoneham[8] specifically postulated in 1993 that the airway length should be independent of the internal diameter.

This literature review was undertaken in reference to tube length and not to external or internal tube diameter. However, recognizing the importance of understanding both the external/internal diameter, we are including the following information. Manufacturers of NPA tubes most often relate the length to the external diameter. It would then be supposed that the internal diameter should be based on the external diameter. However, according to technical data from Rüsch/Teleflex, there is a relationship variant decrease of 2.3 to 3.0mm, based on respective external diameter size of 7.3 to 10.0mm. The external diameter of 7.3 to 10.0mm corresponds with Charrière sizes 22 to 30. This relationship between external and inrternal diameter also can vary based on two other important parameters: the material used to manufacture NPAs (e.g., latex-free, silicon/latex, polyvinyl chloride, silicon/rubber) and the availability of products within one's country.

The NPA tube should be neither too short nor too long to provide sufficient oxygenation. If it is too long, accidental esophageal intubation might occur, with the consequent problems of hypoxia and gastric inflation; or the tip of a long NPA tube could irritate the epiglottis, which would cause a cough reflex. If the NPA is too short, the tip of the tube might end in the vallecula, causing airway obstruction and possibly stimulating cough or gag reflexes or perhaps laryngospasms.[8]

In all emergency training, the focus in teaching must be to continuously observe the clinical condition of the patient after inserting an NPA: (1) The device is inserted beyond the tongue base to stabilize the airway. This may mean inserting the tube up to the flange. (2) If a cough reflex results, that is, if the tip of the tube touches the epiglottis (too deep insertion), the placement of the tube must be corrected, that is, pulled back in possibly 5-mm steps. Millimeter or centimeter markings on the tubes would be helpful for this maneuver. Also, the emergency staff needs significant clinical training in detecting incorrect tube positioning (e.g., insufficient breathing/breath sounds, cough or gag reflex). (3) Upon correct placement, an adjustable flange may be positioned at the nostrils and fastened to minimize the possibility of displacement. Doing this can also provide the emergency technician with visual evidence of NPA movement. (The best training must resemble real-life situations; therefore, more sophisticated training devices need to be developed.)

Another critical aspect is the possible displacement of the NPA resulting from movement of the head and neck, leading to accidental extubation, especially if the tube is too short. Stoneham[8] concluded that the relation between laryngeal structures and the airway is influenced by the head position. This needs to be taken into account in further studies.

Specifically, regarding military members, every soldier could have an NPA tube in their emergency kit, cut to length to meet his or her needs. However, within the European Union certification approval of medical devices, the NPA tube, when cut, loses its required European CE certification. This could become an important matter of discussion with manufacturers of NPA tubes, allowing a certification with approval to cut the NPA. Before deployment, soldiers could have their nose-tip-to-epiglottis distance measured (e.g., by MRI) and then be provided with the appropriate tube. (This would, however, apply only to soldiers and not the average emergency patient.) This again makes it crucial to have a critical understanding of the intraoral distances, anatomy, and NPA devices available.

Comparable studies regarding the optimal length of oropharyngeal airways have been published, for example, by Kim et al.[16] in 2016. They were able to determine the optimal length for oropharyngeal airways (e.g., Guedel tubes), as indicated by the distance of the maxillary incisors to the angle of the mandible. However, NPA study measurements remain heterogenous.

Conclusion

The NPA is a unique, simple piece of emergency equipment, easy to use, inexpensive, and easily available in every trauma bag. It is very effective and shows advantages over oropharyngeal airways, yet it is still used less frequently.[2] Perhaps the guidelines need to be revised because, based on our reviewed studies, methods of sizing NPA tubes are perhaps inaccurate and should no longer apply. There remains a lack of valuable indicators to predict the optimal NPA tube length. The statements in all of the above-mentioned studies were very heterogenous; thus, our study questions could not be fully answered. There is some evidence that the correct length of NPA tubes correlates with the patient's height, independent of gender, and possibly other specific distances in facial anatomic landmarks. The philtrum-/nose tip-to-ear tragus distances seem to be a likely approach; however, the evidence is still inconclusive. The recommendation of measuring nose tip-to-earlobe distance to determine the correct tube length could not be verified by our review.

The possibility of choosing an NPA tube of incorrect length is still high. Current protocols recommend a 13cm tube for females and 15cm tube for males; however, the length must be adjusted according to the patient's height.[3] Quick clinical observation of each patient after NPA insertion is required; having knowledge of the patient's height cannot be depended on in an emergency situation. Height is therefore not a practical parameter for estimating the correct tube length.

What is needed is a quick, easy way to determine the optimal tube length by a certain external facial landmark. It is crucial to examine the correct nose tip-to-epiglottis or nares-to-epiglottis distances with a standardized procedure, such as direct fiberoptic laryngoscopy or radiographic measurements from head MRIs. Distances could be correlated with an external facial landmark, such as nose tip-to-earlobe/tragus or philtrum-to-earlobe/tragus, as previously postulated.[3] Ethnic differences need to be taken into account. Standardized head and neck positioning during the measurements needs to be settled upon.

For emergency personnel, critical training is key. Adjustable tubes of one length and different diameters, or nonadjustable tubes of different lengths, might play a role in efficiency and the time needed to provide an airway. The basics of training must focus on the clinical outcome of the applied device, that is, establishing reliable airway management (solving the A-problem according to the ATLS), stabilizing the patient, and observing clinically the patient's respiration. In all training programs, "gone wrong" examples must be taught, such as adjusting the tube length until the defensive reflexes stop, using another tube length when one appears to be too short, or trying the other nostril if insertion did not work the first time. A basic understanding of how to handle an airway problem with the devices available is the overall goal.

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Author Contributions

AL formulated the initial question. Both authors structured the research requirements. CSP conducted the research and the evaluation. CSP and AL worked together to develop the resulting implementations with regard to the requirements for an NPA and the corresponding training requirements. CSP drafted the article with the assistance of AL. Both authors approved the final manuscript.

Conflict of Interest Statement

The authors declare no conflicts of interest.

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