Available online at www.sciencedirect.com

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

The nasopharyngeal airway: Estimation of the nares-to-mandible and nares-to-tragus distance in young children to assess current clinical practice

Mae Johnson[a], *Alice Miskovic*[a], *Samiran Ray*[c], *Kling Chong*[b], *Melissa Hickson*[b], *Bob Bingham*[a], *Sophie Skellett*[c,*]

[a] *Department of Anaesthesia, Great Ormond Street Hospital for Children, London, United Kingdom*
[b] *Department of Clinical Radiology, Great Ormond Street Hospital for Children, London, United Kingdom*
[c] *Department of Paediatric Intensive Care, Great Ormond Street Hospital for Children, London, United Kingdom*

Abstract

Background: Nasopharygeal airways are used in urgent situations to alleviate airway obstruction. Guidelines for measuring the length of the NPA differ between national and international guidelines, and the evidence base for these measurements is lacking.

The purpose of this study was to measure the nares-epiglottis and nares-vocal cord distances in young children (neonates to 12 years) on 3D reconstructed Magnetic Resonance Imaging (MRI) brain volume scans, and to examine the relationship of these distances with the nares-tragus and nares-mandible distances.

Method: One-hundred and seventy-six scans were reviewed. All patients had undergone MRI 3D brain volume imaging. The anatomical landmarks were identified and the nares-tragus, nares-mandible distances measured and compared to nares-epiglottis and nares-vocal cord distance using Osirix.

Results: The nares-epiglottis and nares-vocal cords distances significantly correlated (p-value <0.05). The nares-tragus distance showed strong correlation with the nares-epiglottis and nares-vocal cord distance compared to the nares-mandible distance (p-value <0.05).

Conclusion: In conclusion, the length of a nasopharyngeal airway in children under the age of twelve years can be predicted using the nares-tragus external anatomical distance minus 10 mm.

Keywords: Airway, Airway obstruction, Airway management, Child, Resuscitation

Introduction

In paediatric resuscitation upper airway obstruction is common. A nasopharyngeal airway (NPA) is a simple, practical device used to relieve upper airway obstruction by separating the soft palate from the oropharynx.[1] The Resuscitation Council (UK),[2] European Resuscitation Council (ERC),[3] and the Advanced Life Support Group (ALSG)[4] recommend that an NPA be inserted as part of basic airway management in a child with airway obstruction. The ability of the NPA to maintain airway patency is critically dependent on both the internal diameter of the airway, and the position of the distal tip of the NPA.[1] The ideal position of the NPA is considered to be that the distal tip should protrude beyond the pharyngeal end of the soft palate but should not pass more distally than the epiglottis.[5] Estimating the length of insertion is based on external anatomical methods, which differ between guidelines. The ERC recommend sizing by measuring the length from the nostril and the angle of the jaw.[3] The RC and ALSG recommend measuring the length from the nostril to the tragus of the ear.[2,4] It is vital for the NPA be sized correctly: if the airway is too short it will fail to separate the soft palate from the pharynx, and if the NPA is too long it can come into the larynx and aggravate the cough and gag

* Corresponding author at: Department of Paediatric Intensive Care, Great Ormond Street Hospital, London WC1N 3JH, United Kingdom.
E-mail address: Sophie.skellett@gosh.nhs.uk (S. Skellett).

https://doi.org/10.1016/j.resuscitation.2019.04.039
Received 12 March 2019; Received in revised form 9 April 2019; Accepted 21 April 2019

reflexes. The ideal position in adults and paediatrics is for the distal tip of the NPA to sit 10 mm above the epiglottis.[5] This allows for movement of the airway relative to laryngeal structures with flexion and extension of the head, without aggravating the gag reflex from epiglottic contact.[5]

These widely taught methods of sizing have limited evidence in the adult population and even less in the paediatric population. In infants under 12-months old a close relationship has been described between nares-vocal cord distance and nose tip-earlobe distance.[7]

The purpose of this retrospective review was to measure the nares-epiglottis and nares-vocal cord distances in young children (neonates to 12 years) on 3D reconstructed Magnetic Resonance Imaging (MRI) brain volume scans, and to examine the relationship of these distances with the nares-tragus and nares-mandible distances on the scans, to establish if one anatomical measurement in paediatrics is more accurate than the other.

Aim

To compare nares-tragus (NT) and nares-mandible (NM) external facial measurements with nares-epiglottis (NE) and nares-vocal cord (VC) distance on MRI scans to evaluate if one measurement correlates more accurately than the other in children.

Materials and methods

After obtaining institutional approval from the Research and Development team (17BA30), we reviewed 3D reconstructed brain volume MRI scans performed at Great Ormond Street Hospital for children in London, a specialist tertiary paediatric centre in the UK. All imaging studies had been performed between September 1996 and January 2016 for medical purposes. Images for children aged from neonates to 12-years old were selected and grouped. For each group, twelve patients were selected by using the randomisation function on Microsoft Excel (RANDBETWEEN1,1000), selecting the lowest numbers first. Electronic medical records (Evolve, version 2.0, Kainos) were used to identify exclusion criteria; craniofacial abnormality, facial trauma, and neurosurgery. If exclusion criteria were met the next patient was selected from the randomisation. Information regarding basic patient characteristics were collected from the electronic medical records including age, height and weight. Of note, despite the careful selection of imaging studies where structures could not be visualised, for example blurred scans; inability to identify land marks; or the head position was not neutral, the entire scan was excluded from the study as measurements could not be accurately made and an alternative scan selected via the randomisation process.

All patients had undergone MRI 3D brain volume imaging with gadolinium. Using OsiriX v.5.8.2 32bit on Apple Mac OS X, T1W images from the brain volume imaging were reformatted in all 3 planes (sagittal, axial and coronal) using the 3D multi-planar reformatting (MPR) tool. Anatomical landmarks for making measurements were done by two researchers independently. The two sets of landmarks were compared if measurement discrepancies arose and a final measurement taken. Using the axis to manipulate the reformatted images, the following anatomical landmarks were identified: (a) right nostril (in axial plane) (b) right tragus (in axial plane) (c) the tip of the epiglottis (in sagittal plane) (d) vocal cords (in sagittal plane) and (e) right angle of mandible (in coronal plane). Using the OsiriX 'point' tool, curve measurements were then drawn sequentially from (a) right nostril to right tragus (in axial plane) (b) right nostril to epiglottis (in axial and sagittal planes (c) right nostril to vocal cords (in axial and sagittal planes) (d) right nostril to right angle of mandible (in axial and coronal planes). The distance for each curve measurement was given in millimetres (mm). The landmarks used are illustrated in Fig. 1 and the anatomical landmarks on MRI illustrated in Fig. 2.

Statistical analysis

Correlation between the between the two landmark distances (NT and NM) and the two target distances (NE and NVC) were sought using Spearman's correlation coefficient. The difference in correlation coefficients for the two landmark distances and target distances were evaluated using Zou's method for dependent overlapping groups.[8] A p-value of <0.05 was considered to be statistically significant.

The ideal position for the tip of the nasopharyngeal prong was a priori decided to be 10 mm above the epiglottis based on Stoneham's description.[6] We allowed a further 5 mm above and below this static point to allow a zone of acceptability. A modified Bland-Altman plot was used to identify the bias and precision of the target distances in estimating the ideal length of insertion.

All analyses were performed using Microsoft Excel (Microsoft Corp, WA) and r (www.cran.r-project.org).

Results

One hundred and seventy-six scans were reviewed. Twenty scans were excluded on the basis of being poor quality, leaving one hundred and fifty-six scans for analysis. Patient characteristics and details of the measured data are presented in Table 1. The imaging studies were from 72 females and 84 males between the ages of 0-years to 12-years (0-months to 144-months).

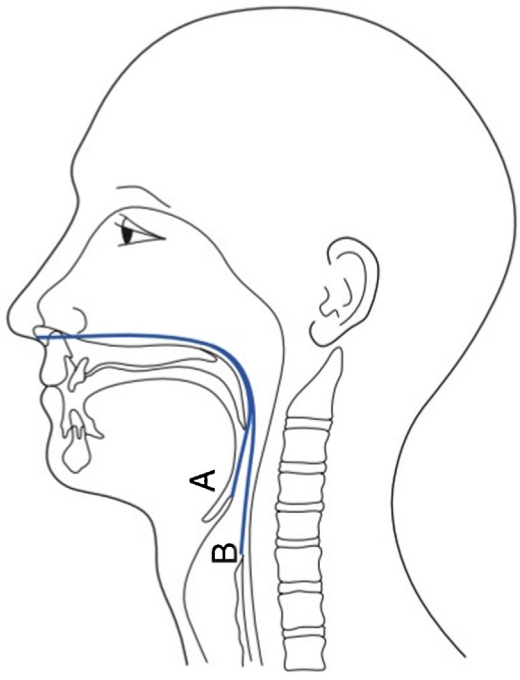

Fig. 1 – Schematic diagram for measurements of the NE distance (A) and NVC distance (B).

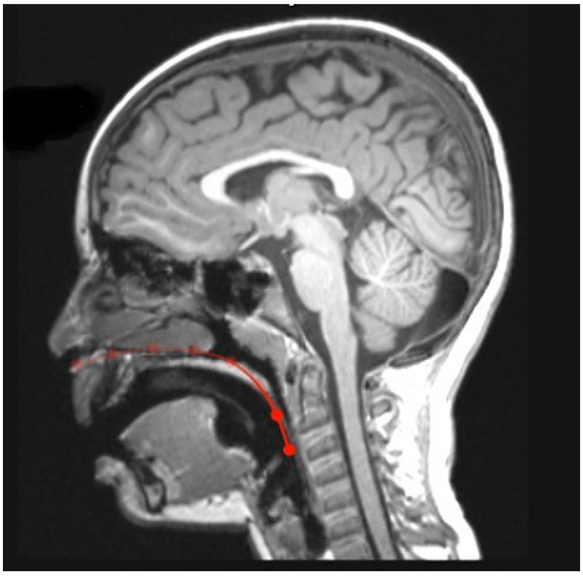

Fig. 2 – Scan examples of measurements taken from MRI images. Red line is anatomical line measured using OsiriX 'point' tool. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

Fig. 3,shows the correlation between the NM & NT with the NE. The Spearman correlation coefficient for NM and NE distance was 0.61. The Spearman correlation coefficient for NT and NE distance is 0.81. The difference between the correlation coefficients is statistically significant (Zou's method 95% CI of differences (0.38, 0.71), p-value <0.05). Fig. 4, shows the correlation between NVC to NM distance and NT distance were also compared again a statistically significant correlation was found between NVC and NT. The Spearman correlation coefficient for NM and NVC is 0.63. The Spearman correlation coefficient for NT and NVC is 0.78. The difference between the correlation coefficients is statistically significant. The correlation between NE and NVC distance was statistically significant, Spearman correlation coefficient 0.96.

Fig. 5 shows the correlation between the NM and NT tragus distances with age (in months). The spearman correlation coefficient for the NM distance and age is 0.60 for the NT distance and age is 0.82. The coefficients are significantly difference (Zou's method, 95% CI of difference (0.37, 0.71), p-value <0.05).

The ideal position of the NPA tip is thought to be 10 mm above the epiglottis. The NM landmark distance underestimated this target distance by a median of 19 mm (IQR 13.75–25.25 mm). In contrast, the NT landmark distance overestimated the target distance by a median of 11 mm (IQR 6–17 mm). Therefore, the NPA measured using the NT landmark distance will have its tip 1 mm below the epiglottis. Using the NT landmark, only 25 (16.0%) measurements ranged within 5 mm of the ideal position (i.e. 10 mm above the epiglottis), compared to only 7 (4.5%) using NM. By correcting for the bias in the NT measurement, i.e. using NT — 10 mm, 71 (45.5%) of NPA tips would be placed within 5 mm of the ideal position.

Discussion

This study shows that there is a significant correlation between the external anatomical NT measured distance compared to the external anatomical measured distance of the NM with the distal tip protruding beyond the pharyngeal end of the soft palate but not passing more distally than the epiglottis. Therefore, our results suggest that the conventional method of sizing the NPA length using the nares-tragus distance minus 10 mm is superior compared to the measured nares-mandible distance.

In adults, the NE distance is known to correlate significantly with patient height, and the NV can be estimated from the patient height[9] or the distance from the NT.[10] Few studies have measured airway dimensions in children. Until now, both the NM and NT distances have been recommended to estimate the ideal NPA length in children.[2–4] However, these conventional methods lack evidence, except in children under 12-months of age where a close relationship has been described between NVC distance and NT distance.[7] Kim and co-workers, showed that the NE and NVC distances between 1 and 10-year old children could be predicted according to patient height and the NM distance. In their study group they found that the NT distance was significantly less than NE and the discrepancy became greater when compared to NM.[9] These complicated formulae based on gender and

Table 1 – Patient characteristic data. Measured NM distance, NE distance and NVC according to age. Distances measured in millimetres (mm). Values are median [IQR (range)] or number.

Age (years)	n	Weight (kg), median (IQR)	Sex (M:F)	Nose-epiglottis distance (mm), mean (sd)	Nose-vocal cord distance (mm), mean (sd)	Nose-tragus distance (mm), mean (sd)	Nose-mandible distance (mm), mean (sd)
0	24	7.8 (6.9–9.7)	14:10	72.9 (7.2)	83.3 (9.1)	77.3 (7.7)	50.9 (4.7)
1	12	11.7 (8.8–13.2)	9:3	84.6 (4.4)	99.3 (6.3)	87 (6.0)	66.2 (7.7)
2	12	15.2 (13.5–16.4)	3:9	86.8 (8.1)	100.9 (9.0)	86.2 (5.2)	61.6 (5.9)
3	12	16.2 (13.7–17.4)	2:10	87.8 (6.9)	102.3 (8.0)	85.6 (5.2)	60.3 (4.0)
4	12	18.1 (17.0–22.0)	4:8	93.8 (6.7)	108.8 (7.2)	92.0 (6.9)	63.8 (5.9)
5	12	23.3 (20.4–23.9)	11:1	98.7 (5.4)	109.6 (6.2)	99.0 (5.8)	67.1 (6.5)
6	12	23.2 (23–27.1)	8:4	99.5 (5.8)	113.4 (8.4)	101.7 (5.1)	68 (3.4)
7	12	25.1 (21.1–27.1)	4:8	99.9 (4.2)	112.5 (4.0)	101.3 (5.9)	64.7 (4.8)
8	12	26 (23.8–29.3)	4:8	95.5 (7.1)	107 (7.4)	94.8 (6.0)	66.2 (8.7)
9	12	38.0 (33.0–40.6)	6:6	100.8 (7.4)	115.2 (8.7)	101.3 (8.4)	68.3 (7.0)
10	12	38.0 (33–40.9)	9:3	100.8 (7.4)	115.2 (8.7)	101.3 (8.4)	68.3 (7.0)
11	11	46.3 (42.9–47.4)	9:3	105.9 (4.0)	121.0 (4.5)	108.6 (7.5)	69.6 (4.9)

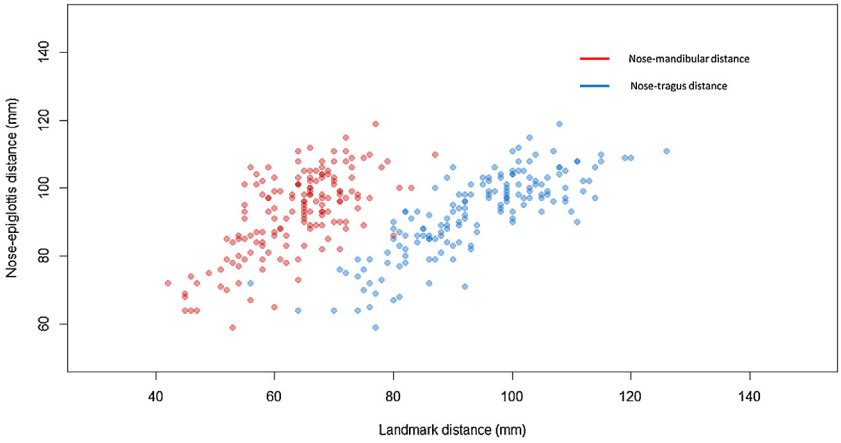

Fig. 3 – Correlation between nose-mandible (red) and nose-tragus (blue distance with the nose-epiglottis distance (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

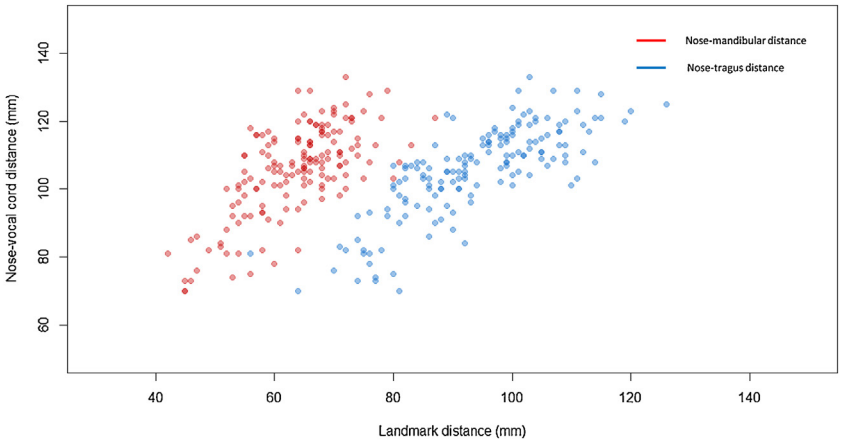

Fig. 4 – Correlation between nose-mandible (red) and nose-tragus (blue distance with the nose-vocal cord distance. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

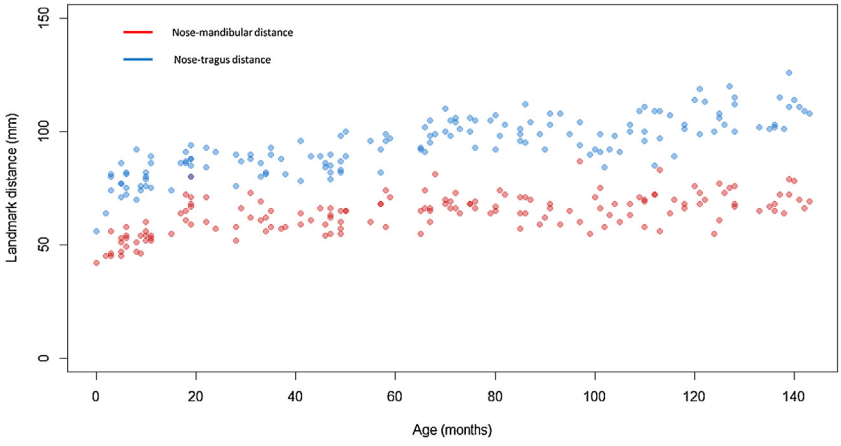

Fig. 5 – Correlation between nose-mandible and nose-tragus distances with age (in months).

height are inappropriate in the case of a clinical emergency with airway obstruction as relief is needed instantaneously. A simple external facial measurement as this study suggests is a quick and simple solution, easily taught to healthcare professionals and widely reproducible by healthcare professionals performing paediatric resuscitation.

It is known that an ideally situated NPA lies within 10 mm above the epiglottis thus separating the soft palate from the posterior wall of the

oropharynx.[6,10] If, using the NM distance to measure an NPA it could lead to the failure in securing the nasal airway patency by having the distal tip of the airway having the distal tip of the airway proximal to the end of the soft palate. A longer NPA will always be superior to a shorter NPA unless impinging on the epiglottis. The NPA measured using the NT landmark in this study distance will have its tip 1 mm below the epiglottis. A NPA impinging on the epiglottis is a serious problem. However, if the NT distance is measured and 10 mm subtracted the NPA should be of appropriate length.

The growth of the vocal tract is non-uniform, and there are sex-differences of the oral and pharyngeal portions of the vocal tract.[11,12] Movement of tracheal tubes in relation to the carina with flexion and extension of the head is a well-recognised problem. It is greatest in small children and neonates due to their shorter laryngo-carinal distance and may lead to accidental extubation or endobronchial intubation and hypoxia.[13] Previous paediatric studies show movements of 10–15 mm occur on flexion and extension of the head.[13] The relative movement of an NPA has not been fully investigated but might be expected to be less than a tracheal tube due to a shorter length. This study has found that 45% of NPA tips would lie within 5–10 mm of the epiglottis further supporting the sizing of NPA using the NT distance.

In adults, the NE distance is known to correlate significantly with the patient height and the NVC can be estimated using the patient height or the distance from the NT.[7] In this study we were unable to analyse correlation with patient height due to lack of measurements. However, the correlation between the NE and NVC distances with patient age and patient weight was analysed. The Spearman correlation coefficient for the NE and patient age (0.79), and patient weight (0.82). The NVC distance also correlated significantly with patients age (0.76) and patients weight (0.81).

There are several limitations and some methodological issues in this study. Firstly, the small numbers of children per group studied makes comparison within age groups difficult. This study suggests that further analysis of the cohort of children of less than 12-months be performed to ascertain whether they can have a NPA sized by both NT and NM measurements. The data showed for children of less than 12-months of age the NE distance is proportionately shorter to the NT distance as in no other age group. In infants the epiglottis is above the soft palate allowing them to breath and drink simultaneously resulting in a shorter distance between the soft palate and the larynx. We suggest for children of less than 12-months of age there should be awareness of the potential for epiglottic irritation should the NPA be too long and that carers should have a much lower threshold for withdrawing the NPA in this situation. It might be prudent in this age range to advance the NPA a few cm deep and advance stepwise to the limit of NT distance −10 mm is reached. Secondly, the majority but not all of the scans were performed under general anaesthetic. Therefore, although the same methods were used to take the measurements, the presence of a laryngeal mask or endotracheal tube may cause some landmark distortion. Scans of poor quality or significant distortion were removed from the study to try and reduce sway. Thirdly, the distance of an NPA to sit above the epiglottis is 10 mm based on historic evidence and has been adopted within paediatric literature without an evidence base presumably related to the larger and floppier epiglottis in the paediatric population. Fourthly, the scans represent a cross section of children seen in our U.K. referral centre and therefore may not represent the demographic population of the U.K. Despite these limitations a clear conclusion can be drawn, and we would recommend NT rather than NM external facial measurement to be used to estimate NPA length.

Conclusion

In conclusion, the length of a nasopharyngeal airway in children under the age of twelve years can be predicted using the nares-tragus external anatomical distance minus 10 mm. There should always be awareness of the risk of respiratory obstruction even with an airway in place.

Disclosures

No funding was received for this study. None of the authors have any conflicts of interest.

REFERENCES

1. Gwinnut C. Lecture notes on clinical anaesthesia. Oxford: Blackwell Scientific Publications; 1997. p. 39.
2. Resuscitation Council (UK).
3. Macinochie IK, Bingham R, Eich C, et al. European Resuscitation Council Guidelines for Resuscitation 2015. Section 6. Paediatric life support. Resuscitation 2015;95:223–48.
4. Advanced paediatric life support manual. 6th ed. January.
5. Gallagher WJ, Pearce AC, Power SJ. Assessment of a new nasopharyngeal airway. Br J Anaesth 1988;60:112–5.
6. Stoneham MD. The nasopharyngeal airway. Assessment of position by fibreoptic laryngoscopy. Anaesthesia 1993;48:575–80.
7. Kim SH, Kim DH, Kang H, et al. Estimation of the nares-to-epiglottis distance and the nares-to-vocal cords distance in young children. Br J Anaesth 2012;816–20.
8. Zou GY. Toward using confidence intervals to compare correlations. Psychol Methods 2007;12:399–413, doi:http://dx.doi.org/10.1037/1082-989X.12.4.399).
9. Shen CM, Soong WJ, Jeng MJ, et al. Nasopharyngeal tract length measurements in infants. Acta Paediatr Taiwan 2002;43:82–5.
10. Roberts K, Porter K. How do you size a nasopharyngeal airway? Resuscitation 2003;56(1):19–23.
11. Han DW, Shim YH, Shin CS, Lee YW, Lee JS, Ahn SW. Estimation of the length of the nares–vocal cord. Anesth Analg 2005;100:1533–5.
12. Vorperian HK, Wang S, Chung MK, et al. Anatomic development of the oral and pharyngeal portions of the vocal tract: an imaging study. J Acoust Soc Am 2009;125:1666–78.
13. Weiss M, Knirsch W, Kretschmar O, et al. Tracheal tube-tip displacement in children during head-neck movement a radiological assessment. Br J Anaesth 2006;96:486–91.