Research

The suitability of finger measurements with tracheal stoma diameter for predicting tracheostomy cannula size

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ABSTRACT

Background: A tracheostomy is a temporary or permanent opening of the trachea followed by a cannula insertion to secure the airway, a common life-saving procedure in otorhinolaryngology. However, tracheostomy cannula sizes vary significantly across manufacturers, with no standardized numbering system, complicating the selection of an appropriate size. The tracheal ring is made of cartilage, so the fingers usually are used as a predictor for cartilage growth in the trachea. **Purpose:** To estimate the little fingers diameter and middle finger length, in order to assess the suitability with the person's tracheostomy cannula size. **Method:** Observational analytical study using a cross-sectional design, analyzing patients who underwent tracheostomy and met specific inclusion criteria. Measurements included the little finger diameter middle finger length, and intraoperative anterolateral tracheal diameter. Data analysis was performed using Pearson and Spearman correlation tests. **Result:** Among 24 participants, adults accounted for 83.3% of cases, while children 16.7%, with a mean age of 54.5 years. The incidence of tracheostomy was more common in males (70.8%), and upper airway obstruction as the main indication (83.3%). The study identified a positive correlation between little finger diameter and tracheal stoma diameter ($r=0.496$, $p<0.05$). Conversely, no significant correlation was observed between middle finger length and tracheal diameter ($r = 0.318$, $p> 0.05$). **Conclusion:** Little finger diameter demonstrated as a potential predictor for tracheostomy cannula size.

Keywords: tracheal cannula diameter, little finger diameter, tracheostomy cannula

ABSTRAK

Latar belakang: *Trakeostomi merupakan pembuatan lubang pada trakea, baik bersifat sementara maupun menetap, yang disertai dengan pemasangan kanula. Tindakan ini penting dalam penyelamatan jalan nafas di bagian THT. Namun, pengadaan kanul trakea oleh produsen sangat bervariasi, dan tidak ada keseragaman dalam penomoran ukuran kanul, sehingga membuat kesulitan dalam penentuan ukuran kanul trakeostomi yang tepat. Cincin trakea tersusun dari tulang rawan, dan untuk mengetahui ukurannya, jari tangan sering digunakan untuk menilai pertumbuhan tulang rawan di trakea.* ***Tujuan:*** *Untuk menilai diameter jari kelingking dan panjang jari tengah, untuk memprediksi ukuran kanul trakeostomi.* ***Metode:*** *Studi observasional analitik dengan desain* cross-sectional. *Pasien yang menjalani trakeostomi dan memenuhi kriteria inklusi, di lakukan pengukuran diameter jari kelingking dan panjang jari tengah, serta diameter trakea intraoperatif. Analisis data menggunakan uji korelasi* Pearson *dan* Spearman. ***Hasil:*** *Didapatkan 24 sampel, angka kejadian trakeostomi pada dewasa 83,3% dan anak-anak 16,7%, dengan rerata usia 54,50 tahun. Laki-laki lebih banyak yaitu 70,8% dengan indikasi tindakan utama adalah obstruksi jalan nafas atas 79.2%. Hasil analisis menunjukkan diameter jari kelingking berkorelasi positif dengan diameter stoma pada trakea ($r= 0,496$, $p<0,05$), dan tidak terdapat korelasi antara panjang jari tengah dengan diameter internal trakea ($r=0,318$, $p>0,05$).* ***Kesimpulan:*** *Diameter jari kelingking dapat digunakan sebagai prediktor ukuran kanul trakeostomi.*

Kata kunci: *diameter kanul trakea, diameter jari kelingking, kanul trakeostomi*

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INTRODUCTION

A tracheostomy tube (TT) comes in various shapes and sizes, with specifications depending on the manufacturing company. There are various TTs available, with different materials, sizes, and styles. The characteristics of each tube, such as the inner and outer diameters and length, are marked on the neck plate. Physicians, intensive care professionals, and surgeons must know the differences between them to choose the tube that best suits the patient's needs.[1] The proper selection and use of an appropriately sized tracheostomy tube, are crucial to minimizing risks and complications associated with TT insertion.[2] The TT must fit perfectly within the trachea, without pressure points, which may develop into granulomas, stenosis, or perforating fistula.[3]

Currently, there is no standardized formula for adults that can be used to predict tracheal diameter. In contrast, for children, several formulas are available to determine the appropriate size of a TT, including the commonly used method of measuring the size of the child's little finger, which is frequently employed by the Anesthesia Department, to determine the size of an endotracheal tube (ETT).[4,5]

Several studies had been done to find alternative methods to determine the correct ETT size. The rationale for using finger measurements was based on evidence that cartilage growth corresponds to tracheal cartilage growth.[6,7] Rajasekhar et al.[8], stating that the width of the fifth finger does not accurately predict the appropriate ETT size in most children. However, the diameter of the little finger might still be useful due to its cost-effectiveness, particularly in patients whose age is unknown.

The length of the middle finger had been shown in previous studies to be a useful predictor for assessing the depth of tracheal tubes in children. In a study conducted by McLean et al. (2020) in the Anesthesia Department in London, a correlation was found between the inner diameter of uncuffed TT and the average middle finger length, for each size of TT. The middle finger has the potential to serve as a better guide for selecting the appropriate TT compared to the age-based formulas commonly used for children.[5,9]

To date, there are no universally accepted guidelines regarding the appropriate size of tracheostomy cannulas for adults. Theoretical considerations suggest that the maximum outer diameter of the tracheostomy cannula should be 1.5 mm smaller than, or approximately two-thirds to three-quarters of the internal diameter of the trachea.[10,11]

The aim of this study was to determine the correlation between the measurements of the little finger diameter, and the middle finger length of patients in predicting the appropriate size of TT in the ENT-HNS Department at dr. Zainoel Abidin General Hospital, Banda Aceh.

METHOD

This was a correlational observational analytic study with a cross-sectional design, conducted from April to September 2024 at the Emergency Room, outpatient clinic, operating room, and inpatient ward of the ENT-HNS Department at dr. Zainoel Abidin General Hospital, Banda Aceh. The inclusion criteria for this study were: patients undergoing tracheostomy for the first time, whether elective or emergency, including both pediatric and adult patients. The exclusion

criteria were: patients with congenital abnormalities or musculoskeletal disorders of the upper limbs, emergency patients with tumor or masses obstructing the anterior neck, malignancies that had destroyed the trachea, patients requiring specific TT, and patients in an unstable condition during intraoperative measurements.

This study used consecutive sampling, and based on the sample size calculation for numerical correlational studies, 24 research samples were obtained.[12]

For patients who met the criteria to be included as research samples and had provided pre-study approval and informed consent, measurements of the diameter of the distal phalanx of the left little finger (5th digity) and the length of the middle finger were performed using a modified digital caliper. During the intraoperative procedure, the laterolateral diameter of the trachea at the 2nd to 4th cartilage rings was measured. Internal diameter of the trachea was calculated by subtracting twice the thickness of the incised tracheal cartilage from the outer laterolateral diameter.

Figure 1. Modified digital Vernier caliper

Analysis of research data was using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp. Released 2019, Version 26.0. Armonk, NY). To see the description and distribution of data, univariate analysis was carried out. To determine the correlation between the little finger diameter to the diameter of tracheal stoma, and the middle finger length to the tracheal diameter which had a ratio data scale, was performed using Pearson Product Moment Correlation test. Furthermore, if the data was not normally distributed, Spearman correlation test with 95% confidence level, would be used.

Ethical clearance for this study was granted by the Health Research Ethics Committee of dr. Zainoel Abidin General Hospital, Banda Aceh with No. 084/ETIK-RSUDZA/2024 on April 5th, 2024.

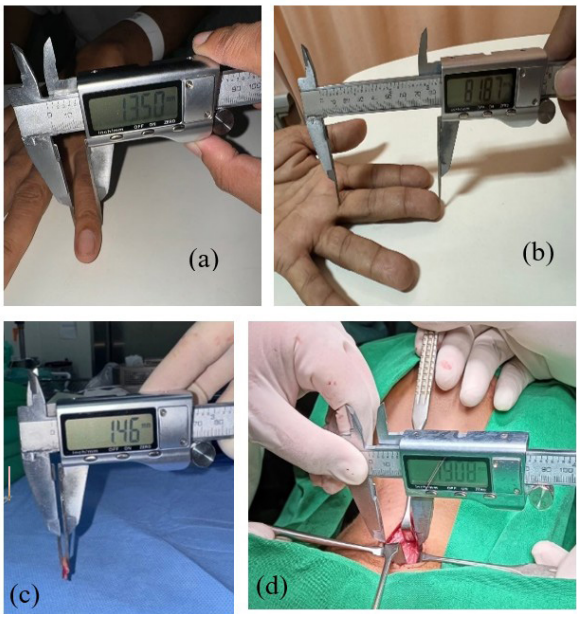

Figure 2: (a) the measurement of little finger diamater, (b) the measurement of middle finger length, (c) the measurement of tracheal cartilago thickness, (d) intraopertive measurement of tracheal diameter.

RESULT

Out of 24 samples in this study we obtained mean age of subjects underwent tracheostomy is 54.50 years old, with the adult age group (>18 years) as many as 20 patients (83.3%), and children as many as 4 patients (16.7%), with higher incidence was found in men (70.8%). Based on the indications for tracheostomy, we found 20 patients with upper airway obstruction (83.3%), followed by the risk of aspiration 3 patients (12.5%), and prolonged intubation 1 patient (4.2%).

The characteristics of the research subjects based on the suitability of the tracheostomy cannula, 8 subjects showed a tracheostomy cannula size that matched the internal diameter of the trachea, and 16 subjects showed a mismatch. The average age in the appropriate tracheal cannula group was 49.5 years, with the adult age group 7 subjects (87.5%). There was a difference in the outer tracheal diameter of the two groups, with a difference of 3.87 mm ($p<0.05$). Characteristic data of the subject could be seen in Table 1.

The average diameter of subject's little finger which underwent tracheostomy was 12.55 mm, and the average internal diameter of the trachea obtained was 12.8 mm. Statistically, the width of the little finger and the internal diameter of the tracheal stoma were positively correlated, with moderate correlation strength. ($r=0.496$, $p=0.014$). The average length of the middle finger undergoing tracheostomy procedure was 7.71 cm. Statistically based on the Spearman correlation test, there was no correlation between the length of the middle finger and the internal diameter of the trachea ($r=0.318$, $p=0.130$). The measurement of little finger and middle finger length, compared to stomal diameter and internal diameter of trachea, in the research subjects could be seen in Figure 3 and 4.

Table 1. Characteristics of research results

Characteristic	Frequency (%)	Tracheostomy Cannula Size Compliance		P value
		Suitable n = 8	Unsuitable n = 16	
Ages (year)	54.50±19.66	49.5 (11–65)	58 (4–70)	0.560
Child	4 (16.7)	1 (12.5)	3(18.8)	
Adult	20 (83.3)	7 (87.5)	13 (81.3)	
Gender, n (%)				0.167
Male	17 (70.8)	4 (50)	13 (81.3)	
Female	7 (29.2)	4 (50)	3 (18.8)	
Trachea outer diameter (mm)*		13.1±1.74	16.97±3.02	0.003
Tracheal cartilage thickness (mm)*		1.41±0.35	1.45±0.22	0.742
Indications for Tracheostomy				0.219
Airway Obstruction	20 (83.3)	6 (75.0)	14 (87.5)	
Aspiration Risk	3 (12.5)	1 (12.5)	2 (12.5)	
Prolonged Intubation	1 (4.2)	1 (12.5)	0	
Lower limit of the cannula tracheostomy (mm)**		7.02 (5.14–7.53)	9.53 (5.73–12.45)	0.005
Outer limit of the cannula tracheostomy (mm)**		7.89 (5.78–8.47)	10.73 (6.45–14.01)	0.005

Data presentation: *) Mean±SD; *) Median (min–max)

Table 1 showed an equal number of subjects for males and females in the suitable tracheostomy group. The same thing was also found in the correlation coefficient value of gender on the internal tracheal diameter ($r=0.308$, $p=l0.120$). It was concluded that there was no effect between gender and the internal tracheal diameter. We similarly found an association between age and internal tracheal diameter ($r=0.079$, $p=0.705$), indicating that age did not influence the size of the internal tracheal diameter.

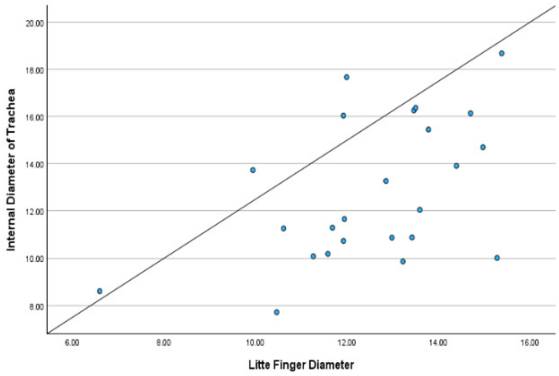

Figure 3. Scatterplot of little finger diameter to internal diameter of tracheal stoma

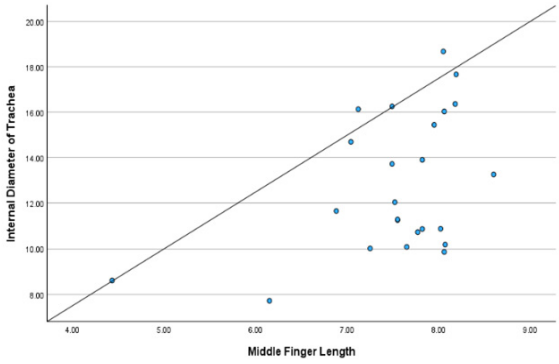

Figure 4. Scatterplot of middle finger length to internal diameter of trachea

DISCUSSION

Among the 24 subjects in this study, tracheostomy procedures were more common in adults (83.3%) compared to children (16.7%), with an average age of 54.50 years, predominantly male (70.8%). According to Corbett et al.[13], the average age of individuals undergoing tracheostomy was 63 years, with men outnumbering women at 65%. This male predominance is attributed to a higher prevalence of obstructive pathologies in the upper respiratory and digestive tracts, such as laryngeal cancer and extensive cervical cellulitis, or infections.[14]

A study from Iran reported a tracheostomy prevalence rate of around 24% in 2019.[15] In India, based on a study conducted by Gupta et al.[16], there were 100 cases of tracheostomy in the period January 2018-January 2020. Yanti et al.[17] research at Muhammad Hoesin Hospital, Palembang, found 71 cases of tracheostomy, from July 2019 to November 2020.

In this study, the average age of participants was 49.5 years, with the adult group showing better alignment compared to children, though two groups showed no significant difference (p=0.560). The male-to-female distribution was equal, with p-values of 0.560 and 0.167, respectively. This indicated that age and gender were not confounding factors or sources of bias in this study. These findings differed slightly from previous studies, which might be attributed to the fact that this study did not use age-based or weight-based formulas to determine tracheostomy cannula size for children. In children aged 1-10 years, age based formula was good correlation with prediction of ETT size.[6] Unlike adults, children require larger cannulas as they grow to provide effective ventilation. An undersized cannula would cause gas leakage and loss of tidal volume with a risk of aspiration, while too large size can cause complications including stridor, croup, and dysphonia.[18]

Regarding the measurement of the external tracheal diameter, a significant difference of 3.87mm was observed between the two groups. Several factors contribute to this difference, including the limitations of intraoperative measurement techniques which could not fully exposing the laterolateral tracheal diameter, and variations in tracheal cartilage anatomy. During surgery, excessive exposure of the lateral tracheal cartilage should be avoided to prevent damage to tracheal blood vessels, and the recurrent laryngeal nerve. Overstretching could also lead to emphysema, which might occur when a patient coughs forcefully with a blocked tracheostomy cannula.[19] The mean tracheal diameter measurement were significantly higher in males than in females. The most

common tracheal type seen was circular type in both females and males. However, there was no significant difference between the sex in tracheal shape.[20,21]

The measurement of latero-lateral outer diameter of trachea in this study influenced the calculation of internal tracheal diameter. This method differed slightly from existing literatures, as no previous studies had measured in situ tracheal diameter directly. Numerous previous published studies showed that tracheal diameter measurements could be conducted with radiological imaging techniques, including CTscans or ultrasound. Several factors might influence the assessment of tracheal size. The presence of tracheitis, a tracheal deviation that could be detected on clinical examination or radiological imaging and can cause increased intrathoracic pressure, the presence of various tumors that can originate from the respiratory system or from nearby structures, can change the anatomy and morphometry of the trachea.[20]

The average diameter of the little finger in this study was 12.55 mm, with a minimum of 6.59 mm in a 4-year-old boy, and a maximum of 15.38 mm in a 56-year-old man. While the little finger diameter increased with age, the maximum value did not correspond to the oldest subject. Previous studies suggested that finger growth ratios were primarily influenced by gender. Men typically have longer fourth fingers relative to their second fingers compared to women (2D:4D). This gender difference in 2D:4D appears in fetuses as early as nine weeks of gestation, and correlates with adult 2D:4D ratios, but is not significant for little finger ratios.[22]

The average of tracheal stoma diameter found was 12.8 mm. There was a positive correlation between the little finger diameter and diameter of stoma, with a moderate correlation coefficient of r=0.496. According to Bhardwaj N et al.[23], using the little finger to predict endotracheal tube (ETT) size showed low strength, as larger tracheal cannulas were often required compared to little finger measurements. However, predicting ETT size with the little finger demonstrated a sensitivity of 98% in children,[24] the measurement of the little finger diameter might be useful due to its cost-effectiveness, particularly in patients whose age was unknown.[8] This method could also serve as an alternative in healthcare facilities with limited resources.[25]

In assessing the correlation between middle finger length and internal tracheal diameter, no significant correlation was found (p=0.130). The average middle finger length in this study's subjects was 7.71 cm. Middle finger length was a continuous variable measured in centimeters, while tracheal cannulas were only available in increments of internal diameter (ID) of 0.5 mm, with diameters expressed in millimeters. Additionally, this study involved both children and adults, unlike other studies where this measurement method was predominantly applied to children.

A different finding was reported by Saikia et al.[9], who identified a strong correlation between uncuffed tracheal cannula size and middle finger length, with a correlation coefficient of r=0.862. Their study, however, was conducted exclusively on children aged 1–12 years.

In conclusion, from this study, we found that the little finger diameter and the diameter of the tracheal stoma were positively correlated with moderate correlation strength, and the little finger could be used as a predictor of tracheostomy cannula size. Nevertheless, the result of this study was still inadequate for clinical purpose. Further objective research with larger sample size should be conducted.

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REFERENCE

1. Vital JM de A, Dias FL, Henriques, Meira MEG da T, Henriques, Meira MAG da T, et al. Tracheostomy Tube Types. In: Farias TP de, editor. Tracheostomy A surgical Giude. Brazil: Springer International Publishing; 2018. p. 23–46.
2. Hess DR, Altobelli NP. Tracheostomy Tubes. Respir Care. 2014; 59(6):956–73.
3. Filho PCM, Assis MMV de, Farias TP de. Pediatric Tracheostomy. In: de Farias TP, editor. Tracheostomy A surgical Giude. Brazil: Springer International Publishing;2018. p. 135–60.
4. Hanamoto H, Maegawa H, Inoue M, Oyamaguchi A, Kudo C, Niwa H. Age-based prediction of uncuffed tracheal tube size in children to prevent inappropriately large tube selection: A retrospective analysis. BMC Anesthesiol. 2019;19(141):1–7.
5. Ritchie-McLean S, Ferrier V, Clevenger B, Thomas M. Using middle finger length to determine the internal diameter of uncuffed tracheal tubes in paediatrics. Anaesthesia. 2020;73(10):1207–13.
6. Bhat RRK, Kamlekar RL, Kulkarni M. Prediction of endotracheal tube size for pediatric patients from the length of the middle finger in comparison with standard age-based formula in South Indian population. Indian Anaesth Forum. 2022;23(2):105–10.
7. Kim HY, Cheon JH, Baek SH, Kim KH, Kim TK. Prediction of endotracheal tube size for pediatric patients from the epiphysis diameter of radius. Korean J Anesthesiol. 2017;70(1):52–7.
8. Rajasekhar MAN, Moningi S, Patnaik S, Rao P. Correlation between ultrasound - guided subglottic diameter and little finger breadth with the outer diameter of the endotracheal tube in paediatric patients – a prospective observational study. Indian J Anaesth. 2018;62(12):978–83.
9. Saikia P, Thottan RS. Length of the middle finger of hand as a simple and reliable predictor of optimal size of uncuffed endotracheal tube in paediatric patients: An observational study. Indian J Anaesth. 2021;65 (11):813–9.
10. Zhou QH, Xiao WP, Zhou HM. Middle finger length-based tracheal intubation depth improves the rate of appropriate tube placement in children. Paediatr Anaesth. 2015;25(11):1132–8.
11. Gupta B, Gupta L. Significance of the outer diameter of an endotracheal tube: a lesser-known parameter. Korean J Anesthesiol. 2019;72(1):72–3.
12. Dahlan MS. Besar Sampel Aksis Korelatif. In: Besar Sampel dalam Penelitian Kedokteran dan Kesehatan. 5th ed. Jakarta: Epidemiologi Indonesia; 2019. p.47–78.
13. Corbett M, Hughes I, O'Shea J, Davey MG, Savage J, Hughes J, et al. X-Ray and CT Scan Based Prediction of Best Fit Tracheostomy Tube - A Pilot Study. Diagnostics. 2020;10(506):1–6.
14. Dolou W, Lawson SLA, Afouda SL, Avakoudjo F, Adjibabi W, Vignikin-yehouessi B. Tracheotomy in ENT at CNHU HKM of Cotonou. Int J Otolaryngol Head Neck Surg. 2021;10:526–35.
15. Alidad A, Aghaz A, Hemmati E, Jadidi H, Aghazadeh K. Prevalence of Tracheostomy and Its Indications in Iran : A Systematic Review and Meta-Analysis. Tanaffos. 2019;18(4):285–9.
16. Gupta A, Gupta P, Mahajan V, Jamwal PS. Tracheostomy in a tertiary care hospital : epidemiology , indications and complications. Int J Otorhinolaryngol Head Neck Surg. 2020;6(5):826–9.
17. Yanti LA, Oktriyani N, Bahar E. Factors Associated with the Incidence of Infection in Tracheostomy Stoma at Mohammad Hoesin Hospital. Biosci Med J Biomed Transl Res. 2021;5(9):842–50.
18. Subramanian S, Nishtala M, Ramavakoda CY, Kothari G. Predicting endotracheal tube size from length: Evaluation of the Broselow tape in Indian children. J Anaesthesiol Clin Pharmacol. 2018;34(1):73–7.
19. Koscielny S. Methods of Surgical Tracheotomy/ Tracheostomy. In: Klemm E, Nowak A, editors. Tracheotomy and Airway. Germany: Springer Nature Switzerland; 2020. p. 43–56.

20. Polat S, Öksüzler M, Öksüzler FY, Özsahin E, Göker P. Radiological and Anatomical Evaluation of the Tracheal Morphology and Morphometry in Turkish Adults. Int J Morphol. 2023;41(6):1625–30.

21. Coşkun ZK, Atalar K, Akar B. Systematic literature study of trachea and bronchus morphology in children and adults. Folia Morphol. 2023;82(3):457–66.

22. Manning JT. Sex differences and age changes in digit ratios: implications for the use of digit ratios in medicine and biology. In: Preedy VR, editor. Handbook of anthropometry: physical measures of human form in health and disease. London: Springer; 2012. p. 841–851.

23. Bhardwaj N, Sayal K, Singh D, Thakur A, Kumar V. Comparison of ultrasonographic estimation of endotracheal tube size with age-based formula and diameter of little finger in pediatric patients. Int J Res Rev [Internet]. 2020;7(7):1. Available from: www.ijrrjournal.com

24. Singh S, Jindal P, Ramakrishnan P, Raghuvanshi S. Prediction of endotracheal tube size in children by predicting subglottic diameter using ultrasonographic measurement versus traditional formulas. Saudi J Anaesth. 2019;13(2):93–9.

25. Putra SR, Gde T, Senapathi A, Agung IG, Utara G, Ryalino C, et al. Accuracy Comparison between Four Methods of Endotracheal Tube Diameter Estimation for Pediatric Patients :An Observational, Cross-sectional Study. Bali J Anesthesiol. 2022;6(3):177–81.