Using Middle Fingertip to Rascette Line Measurement as a Novel Approach in Determining the Endotracheal Tube Depth for Filipinos: A Pilot Study

Joel P. Cabañas, Marcos D. Bito-onon

Department of Anesthesiology, West Visayas State University Medical Center, Philippines
Corresponding author: joelcabanas123@gmail.com; marx_starry@yahoo.com

Abstract

The fundamental responsibility of an anesthesiologist is to establish airway patency during general anesthesia to ensure adequate ventilation and oxygenation. Incorrect placement of the endotracheal tube, over or under-insertion, is associated with serious complications. Determining the correct depth of the endotracheal tube is crucial and should be individualized. This study aims to determine if middle fingertip (MFT) to Rascette line (RL) or "wrist line" measurement correlates with acceptable endotracheal tube (ET) depth during orotracheal intubation. This was a prospective, analytical cross-sectional pilot study design. The measured distance from the MFT to RL (cm) of each patient corresponds to predetermined ET depth. After intubation, a chest x-ray was performed to measure the distance of the ET tip from the carina. The average MFT to RL measurement for Filipinos was 18.79cm (± 1.08) with a mean value of 19.81cm (± 0.99) in males and 18.28cm (± 0.70) in females. Utilizing the MFT to RL measurement, the overall mean distance of the ET tip from the carina was 3.17cm (±1.25), 2.91cm (±1.22) in females, and 3.66cm (±1.36) in males. This was within the acceptable distance of 2-5cm to ensure safe ET placement in the trachea. Out of 54 patients, 85.19% had ET tips 2-5cm away from the carina and 96.29% with ET tips positioned ≥1cm above the carina. In conclusion, MFT to RL measurement is an acceptable technique to determine endotracheal tube depth during orotracheal intubation and estimate correct ET placement in the trachea.

Keywords: Middle fingertip, middle fingertip to Rascette line measurement, orotracheal intubation, Rascette line or wrist line

INTRODUCTION

Endotracheal intubation is the gold standard for airway management and the most commonly performed procedure in the fields of anesthesiology, emergency medicine, and critical care (Varshney, 2011). One of the fundamental responsibilities of an anesthesiologist is to establish airway patency during general anesthesia to ensure adequate ventilation and oxygenation (Miller et al., 2015). Incorrect placement and inappropriate depth of endotracheal tube within the airway are associated with serious complications. Over-insertion may result in endobronchial intubation, one-lung ventilation, and hypoxia (Lee et al., 2009). Unintended bronchial intubation accounts for 4% of the adverse respiratory events in pediatric patients and 2% among the adult population. In

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contrast, under-insertion of the tube may inappropriately place the inflated cuff over the vocal cords leading to vocal cord trauma, laryngeal nerve compression, and inadvertent extubation (Mukherjee, Ray, & Pal, 2014). Therefore, determining the correct depth of the tube is crucial and should be individualized.

There are several methods of estimating optimal endotracheal tube length in orotracheally intubated adult patients. This includes auscultation for bilateral breath sounds along with symmetrical chest expansion (Choi et al., 2012), and palpation of the cuff at the suprasternal notch (Goodman et al., 1976). However, auscultation alone is still inadequate for assessing the actual depth of endotracheal tube insertion (Yao, 2009) and cannot rule out endobronchial tube placement. In Thai patients, they utilize the Chula formula which is 4cm+(patient height in cm/10cm) to calculate ET depth (Techanivate et al., 2005). Other methods include post-intubation fiberoptic bronchoscopy and chest radiography to identify the depth of the endotracheal tube in the trachea. However, these techniques require expertise to handle, are not routinely available in the operating theater and are costly (Mukherjee et al., 2014).

The standard insertion tube depth for orotracheal intubation is 21cm for females and 23cm for males (21/23 rule) among Caucasians (Goodman et al., 1976). Such rough estimations however can lead to inadvertent endobronchial intubation, especially among Filipinos with expected shorter tracheal length. In the Austrian population, the depth of ET from the central incisor should be 20cm in females and 22cm in males (Sitzwohl et al., 2010). Park et al. (1996), reported that ET depth is safe at 20cm for Korean males and 18cm for females, whereas Varshney et al. (2011), reported that the ET depth in the Indian population was 20.26cm for males and 18.23 for females secured from the right corner of the mouth.

Another study by Ong et al. (1996), reported that the use of 23/21 rule in Asian populations increases the risk of main stem intubation. This could be because Asians are generally of shorter stature in comparison to the Western population, especially Caucasians. Individualized measurement of endotracheal tube length provides optimal tube depth, avoids malpositioning, and significantly limits tube adjustment after successful intubation (Ong et al., 1996). Amos et al. (2018), also found that the depth of intubation is directly related to height and with a linear correlation in both male and female populations across all ethnicities (Malay, Chinese and Indian). At present, there has no existing report or data on the optimal endotracheal tube depth specific for Filipinos.

The general objective of the study is to determine if the middle fingertip to Rascette line measurement correlates with acceptable endotracheal tube depth during orotracheal intubation. Specifically, the study aims; 1) To determine the average tube length of patients undergoing orotracheal intubation. 2) To determine if there is a significant difference in the tube length between males and females. 3) To determine if the topographic measurement from the middle fingertip to Rascette line will result in equal breath sound on auscultation, symmetrical chest rise, oxygen saturation of 98-100%, and normal end-tidal carbon dioxide (ETCO2) levels. 4) To determine if topographic measurement from middle fingertip to Rascette line will result in endotracheal tube tip positioned above the carina.

METHODS

Research Design

This was a prospective, analytical cross-sectional pilot study design.

Setting and samples

This study was conducted at the Operating Room Complex of a Tertiary Hospital from March to September 2022. A total of 54 adult Filipino patients, 19 years old and above, were under service accommodation for general anesthesia via orotracheal intubation through direct laryngoscopy or video laryngoscopy. The respondents were selected purposively for the conduct of research regardless of gender. With the increasing cases of COVID-19 in the community during the conduct of the study, the operation of elective cases in the institution where the study was conducted was suspended from August to September 2021. This dramatically decreased the number of possible participants in the study because almost 90% of study participants were from elective surgery cases. Thus, this research was amended into a pilot study with 54 sample size study participants and was approved by the Unified Research Ethics Review Committee. Inclusion criteria were the following: American Society of Anesthesiologists (ASA) 1 to 3 adult Filipino patients 19 years and above of either sex, scheduled for emergency or elective surgery under general anesthesia via orotracheal intubation through direct laryngoscopy or video laryngoscopy. All patients included in the study had negative RT-PCR results for Covid-19. Exclusion criteria were the following: patients who refused to be part of the study and those who did not sign the informed consent, American Society of Anesthesiologists (ASA) 4 to 6, and patients with severe anatomical defects of the face, neck, and upper airway. Patients who will undergo nasotracheal intubation, bronchoscopy, or fluoroscopy-guided brush biopsies, with findings of pneumothorax or atelectatic lungs, and pregnant were excluded. Patients with hand deformities from trauma, such as burns resulting from contractures on fingers and wrist area, amputation of middle fingers, or both hands were also excluded. Patients scheduled for operation at the Covid Operating Room and people with mental disorders due to psychological or developmental disorders who could not give his/her consent were also excluded from the study.

ASA-PS American Society of Anesthesiology Physical Status Classification- used to predict anesthetic and surgical risk prior to a procedure which is based upon the patient's physical health status

ASA 1: a normal healthy patient
ASA 2: a patient with a mild systemic disease
ASA 3: a patient with a severe systemic disease that is not life-threatening
ASA 4: a patient with a severe systemic disease that is a constant threat to life
ASA 5: a moribund patient who is not expected to survive without the operation; a patient who is not expected to survive beyond the next 24 hours without surgery
ASA 6: a brain-dead patient whose organs are being removed with the intention of transplanting them into another patient

"E" – if an emergency procedure

Measurement and data collection

The researcher was the one who performed the procedural steps in measuring the middle fingertip to Rascette line of all study participants who consented, using the same calibrated measuring T-square. The Rascette line or wrist line is located where the palm and the wrist join (Evron et al., 2007). Approved data collection form was utilized using number coding for each study participant to collect information such as the individualized measurement for the middle fingertip to Rascette line, the distance of ET tip away from the carina based on chest x-ray, and other general information of each patient.

Preoperative procedure: A standard preoperative evaluation form, approved and registered with the Quality Assurance Office of WVSU-MC, was administered to the patient by the anesthesiologist in charge. The assessment was done by the researcher based on the inclusion and exclusion criteria. Once qualified, the patient was invited by the researcher to participate in the study. As the patient agreed, the consent form either in English or Hiligaynon was explained to the patient, and once amenable he/she was made to affix his/her signature. The qualification of the researcher included the following: licensed medical doctor and anesthesiology resident in training.

Measurement of the middle fingertip to Rascette line was performed with each patient using the same calibrated T-square. The patient was flat on bed in a supine position with the palmar aspect of the hand facing upward. The researcher placed the T-square starting from zero calibration on the tip of the patient's middle finger and extended it up to the most proximal Rascette line or wrist line. Measurement of the middle fingertip to Rascette line was performed by the investigator alone to reduce inter-observer variation.

Induction of anesthesia: At the time of surgery, the patient was positioned on the operating table with the head in a neutral position and provided with appropriate head support or pillow. ASA standard monitors (2020) such as non-invasive blood pressure (NIBP), electrocardiogram (ECG), pulse oximeter, and capnography (if available) were provided to the patient. Preoxygenation with 100% oxygen via a fitted face mask for three to five minutes was performed prior to induction of general anesthesia for elective cases. For emergency operations where rapid sequence induction (RSI) was warranted, the anesthesiologist in charge preoxygenated the patient by instructing him/her to have eight breaths with full inhalation and exhalation (maximum capacity breath) for 60 seconds or four full breaths in 30 seconds. Adequate preoxygenation was essential to provide an increased length of time before oxygen desaturation occurs in an apneic patient while the anesthesiologist was securing the airway. The anesthesiologist in charge decided on his/her preferred anesthetic medication for induction appropriate for the clinical and hemodynamic status of the patient. Medications given during induction may vary according to anesthesiologist preferences depending on the case of the patient. Once the patient was paralyzed and the condition was appropriate for intubation, laryngoscopy was performed using video laryngoscope C-MAC D-blade (Karl Storz) or Macintosh blade size 3 or 4.

The anesthesiologist in charge of performing the intubation made sure that the pre-determined tube measurement was at the level of the patient's right corner of the mouth. Once the identified level of the tube was on the right corner of the mouth, the anesthesiologist halted further tube insertion while ensuring that the ET cuff had passed through the vocal cords. The assistant anesthesiologist performed 5-point auscultation to assess for bilateral and equal breath sounds at the same time while observing bilateral chest rise. Monitoring with capnography if available to confirm endotracheal tube placement was observed with the presence of six consecutive waveforms. Pulse oximetry reading was also documented within one minute after tube placement. Endotracheal tube cuff inflation was done using an appropriate volume of air. The endotracheal tube was secured using a surgical plaster on the right corner of the mouth while maintaining the head and neck in a neutral position.

Post-intubation: A post-intubation chest radiograph using a portable x-ray machine was done to measure the distance of the endotracheal tube tip relative to the carina. Fiberoptic bronchoscopy was not utilized to confirm ET tip location in this study because it is an aerosol-generating procedure. The acceptable distance of ET tip to carina in this study was between two to five centimeters (Amos, et al., 2018). If the post-intubation x-ray reading of the tube to carina distance was not within the acceptable value, the anesthesiologist in charge will deflate the cuff

and adjust the tube until the acceptable ET tip to carina distance has been achieved. The measured ET to carina distance after tube adjustment was also recorded in the data collection form. Collected data underwent review for completeness of information needed and was secured in a brown envelope at the office of the Department of Anesthesiology.

Data analysis

Data were analyzed using SPSS version 22 and presented as mean ± SD, number of patients and percent. Continuous variables (such as age, height, weight, ET tip to carina distance, and middle fingertip to Rascette line measurement) were presented as mean ± SD. Categorical variables (Mallampati Class, patients needing ET repositioning, patients with clear breath sounds after intubation) were presented as absolute numbers (n) and percentages (%). Mann-Whitney U and Wilcoxon W test was used to analyze the statistical difference between males and females with an alpha value of 0.01. Pearson correlation plot was also utilized to analyze the correlation between the middle fingertip to Rascette line measurement and height.

Utilizing the Wilcoxon test based on the results presented, a two-tailed (18.79-19.3.17) 15.62-point effect with an alpha of .01 yields a power (1-B) of 0.81 from the 54 respondents who represents as sample size in the study conducted.

Utilizing the Pearson test, a total sample size of 54 indicates the minimum number of data points needed to collect for both variables to have a reasonable chance of detecting a correlation of the specified effect size at the chosen significance level (0.01) and power level (0.945).

RESULTS

Out of 54 patients, ten underwent an emergency operation and 44 were under elective surgery. Overall, 6 (11.11%) patients were categorized as ASA 1, 32 (77.78%) as ASA 2 and 6 (11.11%) were ASA 3. There were 36 (66.67%) female and 18 (33.33%) male patients with ages 19 to 69 years old. The standing height of patients ranged from 147 to 175cm (Table 1).

Table 1. Clinico-demographic profile of patients.

	Frequency (N)	**Percentage (%)**
Total	54	100%
Sex		
Male	18	33.33%
Female	36	66.67%
ASA-PS Classification		
I	6	11.11%
II	32	77.78%
III	6	11.11%
Height (cm)		
145-156	20	37.04%
157-166	26	48.15%
167-175	8	14.81%

All patients after intubation had symmetrical chest expansion, and equal breath sounds, with oxygen saturation of 99 to 100%. Single-attempt intubation was successfully performed on all patients using a Macintosh blade or video laryngoscope D-blade. All patients were extubated immediately after surgery (Table 2).

Table 2. Percentage of patients with symmetrical chest expansion, equal breath sounds, oxygen saturation and end tidal carbon dioxide after intubation.

Total	**Number (54)**	**Percent (100%)**
Symmetrical chest expansion	54	100%
Equal breath sounds	54	100%
Oxygen saturation (99-100%)	54	100%
End Tidal Carbon Dioxide (EtCO2) monitoring		
With monitoring	24	44.44%
Without monitoring available	30	55.56%

The average middle fingertip (MFT) to Rascette line (RL) measurement for Filipinos was 18.79cm (± 1.08). In males, it ranged from 17cm to 21cm with a mean value of 19.81cm (± 0.99) while in female patients it ranged from 17cm to 20cm with a mean value of 18.28cm (± 0.70). The Mann-Whitney U and Wilcoxon W test output shows that there was a significant difference in the mean rank of middle fingertip to Rascette line measurement between males and females with $p< 0.01$. Utilizing the MFT to RL measurement as predetermined ET depth, the overall distance of ET tip to the carina has a mean value of 3.17cm (±1.25), 2.91cm (±1.22) in females, and 3.66cm (±1.36) in males (Table 3).

Table 3. Mean values of middle fingertip to Rascette line measurement and distance of ET tip to carina among Filipino patients.

	Middle Fingertip to Rascette Line Measurement (cm)		**Distance of ET tip to Carina (cm)**	
	Mean	SD	Mean	SD
Sex	18.79	1.08	3.17	1.25
Male	19.81	0.99	3.66	1.36
Female	18.28	0.70	2.91	1.22

Out of 54 patients, 46 (85.19%) had ET tips 2-5cm away from the carina which was within the acceptable value. However, 6 (11.11%) and 2 (3.7%) patients had endotracheal tubes <2cm and >5cm away from the carina respectively. Generally, 96.29% of patients had an ET tip positioned ≥1cm above the carina, while 1 patient with ET tip directly at the carina and 1 patient with right mainstem endobronchial intubation. The farthest distance of the ET tip from the carina in the study measures 6.1cm (Table 4).

Table 4. Middle fingertip to Rascette line measurement and distance of ET tip to carina.

	Distribution of patients based on middle fingertip to Rascette line measurement (cm).									
ET tip to carina distance (cm)	17	17.5	18	18.5	19	19.5	20	21	total	%
<2	1	1	2	0	0	0	2	0	6	11.11%
2-5	2	1	18	4	5	3	10	3	46	85.19%
>5	0	0	1	0	0	0	1	0	2	3.70%
Total	3	2	21	4	5	3	13	3	54	100%

Using the Pearson correlation plot, there was a significant relationship between middle fingertip to Rascette line measurement and the height of patient with covariance (5.034) and correlation (0.756) values both positive, with $p<0.01$. Thus, taller patients tend to have longer MFT to RL measurements (Figure 1).

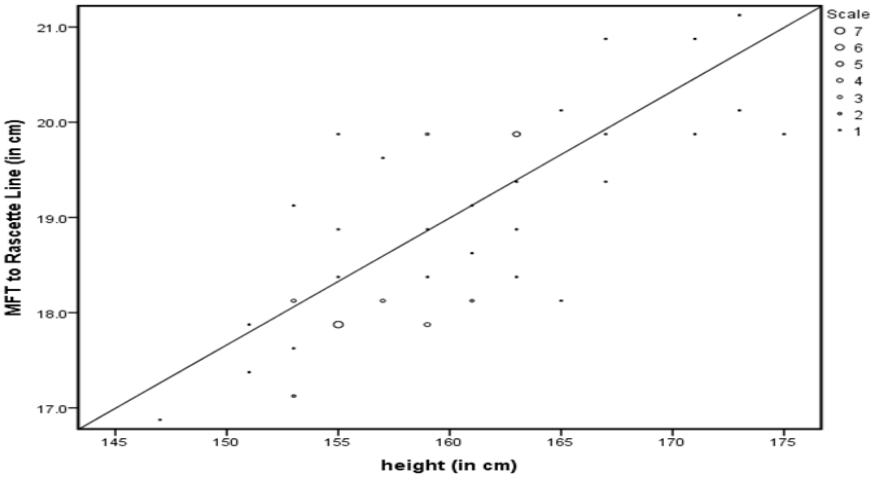

Figure 1. Correlation of middle fingertip to Rascette line and height using Pearson correlation plot.

DISCUSSION

This pilot study was the first to provide data on acceptable endotracheal tube depth during orotracheal intubation among adult Filipinos using the middle fingertip to Rascette line as a topographic measurement.

The result of our study is comparable to the study done by Techanivate et al. (2005), on 100 adult Thai patients utilizing the Chula formula which is 4cm+(patient height in cm/10cm) to calculate ET depth. In their study, the mean ET depth was 19.6cm in females and 20.8cm in males. The mean distance from the ET tip to carina was 3.0cm in females and 4.1cm in males measured through fiberoptic bronchoscopy. The mean distance from the vocal cords to the upper border of the ET cuff was 4.6 cm in females and 4.5 in males. This study has 99% accuracy in estimating the proper position of the orotracheal tube provided there is a known height of the patient for the formula. However, in the present study, the distance of vocal cords from the upper border of ET cuff was not possible to measure through a chest x-ray.

The use of the standard 21/23cm rule for endotracheal depth was studied in 83 Caucasian patients by Roberts et al. (1995). This resulted in 97% acceptable ET placement, with a mean distance of ET tip from carina of 3.45cm for females and 4.1cm for males. For Filipinos with shorter stature, the use of the 21/23 cm rule could possibly result in endobronchial intubation for several patients. Ong et al., (1996), reported in their study that using the 21/23 rule in Asian populations increases the risk of endobronchial intubation. According to (Sitzwohl et al., 2010), the use of 21/23 conventional methods for ET depth will result in deep intubation and recommended that the depth of ET from the central incisor should be 20cm in females and 22cm in males. Park et al. (1996), reported that ET depth is safe at 20cm for Korean males and 18cm for females, whereas Varshney et al., (2011), reported that the ET depth in the Indian population was 20.26cm for males and 18.23 for females secured from the right corner of the mouth. Hence, endotracheal tube depth should be individualized considering the ethnicity and height of patients accompanied by a thorough physical examination, clinical assessment, and appropriate monitoring.

Amos et al. (2018), analyzed 708 intubated ICU patients admitted to Ng Teng Fong General Hospital Singapore and found out that in all ethnic groups (Chinese, Malay, Indian, etc.) the average ET depth was 22cm, while 21cm in females and 22cm in males. Their mean ET depth was longer compared to our study which was 18.79cm among Filipinos, 18.28cm in females and 19.81 in males. The large difference is probably due to the height of the different ethnic groups that were included in their study population. There was no occurrence of perioperative airway events in all study participants and all patients were immediately extubated post-operatively. Brunel et al. (1989), reported that in 5% with mainstem bronchial intubations, half of these patients still present with equal bilateral breath sounds on auscultation. This is possible especially if the murphy's eye of the ET tube faces towards the contralateral mainstem bronchus. Endobronchial intubation was more common in females than in males and frequently occur during emergency intubations (Brunel et al., 1989).

In a pilot study done by Evron et al. (2007), the acceptable ET tip to carina distance is between three to five centimeters. The result of the study showed that the mean ET tip to carina distance was 2.7cm in females and 3.4 cm in males using the 21/23 cm rule. Conrardy et al. (1976), recommended that in patients with the head in neutral position, the acceptable endotracheal tube tip to carina is 3-5cm. This is to ensure that during unanticipated repositioning of the head the tube will not lead to accidental endobronchial or extubation. However, Amos et al. (2018), found out that out of 708 intubated ICU patients, ET tip to carina distance was 2-5cm in 58.7%, >5cm in 26.6%, 2cm in 12.4% and 2.3% had endobronchial intubation. Thus, the authors adapted the 2-5cm acceptable value from Amos et al. (2018), with Asians study population. According to Kim et al. (2009), in adult patients under general anesthesia, neck extension resulted to partial withdrawal of the tube 1.7cm away from the carina and 1.3cm during neck flexion.

Based on Pearson correlation coefficient analysis, there was a positive relationship between middle fingertip to Rascette line measurement and height. Taller patients tend to have longer middle fingertip to Rascette line measurements. Endotracheal tube depth directly correlates to the height of the patient. Varshney et al. (2011), found that the upper airway length has a significant correlation with height, arm span and vertebral column length ($p<0.01$). Therefore, shorter patients require more vigilant and careful evaluation during endotracheal intubation.

This present study also documented the entire length from the right corner of the mouth to carina. With the patient in a neutral supine position, this can be derived by adding the middle fingertip to Rascette line measurement and the measured distance from the endotracheal tube tip to carina. The distance from the right corner of the mouth to carina in male patients ranged from 21.1 to 26.1cm with a mean value of 23.46cm (±2.06) and in females, it ranged from 17.5 to 24.4cm with a mean value of 21.19 cm (±1.73). This is comparable to the study done by Kumari et al. (2019), where they used a fiberoptic bronchoscope to measure the distance from the lip to carina which was 21.3cm in females and 22.9cm in males. Varshney et al. (2011), reported that the distance from lip to carina was 21.62 cm (±1.34) in females and 24.32cm (±1.81) in males.

The present study confirmed the applicability and reliability of the middle fingertip to Rascette line measurement as an estimate of endotracheal tube depth. A simple method such as this to determine the appropriate tube depth for intubation could help avoid endotracheal tube malpositioning. The recommended lengths of the ET for orotracheal intubation have been proposed based on patient height and suggested formulas which vary with different ethnic groups.

CONCLUSION

In conclusion, the middle fingertip (MFT) to Rascette line (RL) measurement was an acceptable technique to determine endotracheal tube (ET) depth during orotracheal intubation. The mean airway distance is shorter among the Filipino population with an average endotracheal depth of 18.28cm (± 0.70) for females and 19.81cm (±0.99) for males. The success rate of properly positioned ET tip ≥1cm above the carina was 96.29% in the present study, with 85.19% within the acceptable ET tip to carina distance of two to five centimeters. Using the MFT to RL measurement provides individualized ET depth and prevents malpositioning during intubation. This technique may be useful during emergency intubations, particularly in settings where a chest x-ray is not readily available to assess the level of the endotracheal tube tip in the trachea. The findings of this study can greatly contribute to the practice of medicine in the Philippines.

This study had some limitations. The study was not able to document the distance from the vocal cord to proximal border of the cuff because the ET cuff is not visible using x-ray. The distance from the vocal cord to proximal border of the cuff should be adequate to avoid critical incidents of inadvertent extubation and accidental compression of recurrent laryngeal nerve. Further study is recommended using a larger sample size or in a multi-center, with an equal number of male and female study participants, which would help establish the use of this technique. It is also recommended to expand the study participants including the pediatric population 18 years old and below for they are at higher risk of endotracheal tube malpositioning. The use of fiberoptic bronchoscopy would be essential if further studies would include determining the distance of the vocal cords to the proximal border of the endotracheal tube cuff.

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