

Chula Formula is recommended in Estimating the Length of Tracheal Tube Insertion in Patients Receiving Mechanical Ventilation in Intensive Care Units in the Absence of Chest X-Ray

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ABSTRACT

Background: Chest X-Ray (CXR) is one of the most effective ways of confirming the length of the tracheal tube (TT) insertion. However, some intensive care unit in developing countries has no sufficient facilities. This study aims to evaluate the accuracy of TT length insertion using the Chula formula and Colombian formula in patients receiving mechanical ventilation in intensive care units.

Methods: This study is a comparative observational study of 50 adults in the Intensive care unit, divided into two groups. Group A used the Chula formula for TT length insertion (n= 25) and Group B used the Colombian formula (n= 25). The TT length insertion accuracy was evaluated using radiological parameters. Statistical analysis used: Data were analyzed statistically using the T-test and Chi-square test.

Result: The Chula formula is significantly more precise than the Colombian formula in estimating the length of TT insertion based on the radiographic parameters of the TT length insertion right midway between the medial tip of the clavicle and TT located in the T3 or T4 vertebrae (p <0.05), but not significantly different in the two other parameters.

Conclusion: Both the Chula formula and the Colombian formula can estimate the length of TT insertion in adult patients. However, the Chula formula is more recommended in the length of TT insertion and benefit in the ICU with insufficient CXR.

Keywords: airway management, Chula formula, Colombian formula, TT, ICU

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INTRODUCTION

Mechanical ventilation is an essential life-saving modality and is widely used in Intensive Care Units (ICU).¹ A retrospective cohort study from six states in the US reported that of 6.469.674 hospitalizations, 180.326 (2.8%) received invasive mechanical ventilation.² Tracheal intubation is one of the most important and most commonly performed procedures in anesthesiology, emergency medicine, and critical care.³ The wrong insertion placement of the tracheal tube (TT) causes some complications in the airway.⁴ The length of TT insertion becomes one of the most common problems in TT placement.⁵ TT that places too deep can cause the carina's stimulation and cause sympathetic stimulation resulting in the formation of tachycardia, hypertension, bronchospasm, hyperinflation of the lung and increases the risk of pneumothorax. At the same time, an unventilated lung can develop atelectasis and develop systemic

hypoxemia. Too shallow TT insertion possibly hit the vocal cords so that the inflammation can trigger sympathetic stimulation, trauma, repetitive compression of the laryngeal nerve, and an increased risk of involuntary extubation.^{6,7}

The traditionally length TT insertion was 21 cm in women and 23 cm in men. Several scientific publications show that more than 33.4% of TT are incorrectly placed. Inaccurate TT placement was more common in women than in men (61.9% vs. 38.1%).⁸ Research in 2005 showed that height had a relationship with the optimal depth of TT insertion. Based on this relationship, it is formulated into the Chula formula $\{(height\ (cm): 10) + 4\}$. Based on Chula formula, TT tip insertion length at least 2 cm above the carina, which was confirmed using fiber-optic bronchoscopy.^{8,9} Other techniques have been described to confirm the length of TT insertion, including palpation of the cuff on the suprasternal notch, X-rays, and fiber-optic bronchoscopy.

Auscultation at 5 points remains the most common method to ascertain the position of the TT because of the feasibility and ease of doing the methods.^{9,10} Chest X-Ray is one of the most effective ways of confirming the length of the TT insertion.¹¹

Not all hospitals, especially in developing countries, provide a CXR to help anesthesiologists ensure TT length insertion accuracy. This study evaluates the accuracy of the TT length insertion based on the height-based formula (Chula formula) and the combination of gender and height (Colombian formula) confirmed using X-rays in ICU patients of Dr. Saiful Anwar Hospital to provide an alternative method in estimating the accuracy of TT insertion.

METHODS

This study is a comparative observational cross sectional study comparing the length of the TT length insertion using two different formulas, the Colombian formula and the Chula formula. The research method was approved by the Health Research Ethics Committee of Dr. Saiful Anwar General Hospital. The patients enroll in this study given informed consent to participate in the study.

The study was conducted on 50 adult patients admitted to the Intensive Care Unit (ICU). The study inclusion criteria, including adult patients with mechanical ventilation through tracheal intubation, used cuffed TT, and the patient's family agreed to be the research subject. Patients with a history of oral, maxillary, tracheal, and laryngeal pathology (such as tracheostomy and upper airway surgery), patients with anatomical abnormalities of the airway, and the patients' height <145 cm were excluded from the study.

Patients are prepared to undergo standard general anesthesia. Each patient was provided with all standard cuffed TT sizes ranging from number 6.5 to 7.5. Anesthesia is induced and patients given neuromuscular blocking drugs, then the airway and positive ventilation are maintained with a mask. The estimation of TT size was done using ultrasonography.

After the intubation procedure, the length of TT insertion is calculated using the Colombian formula by Gomez et al.⁹ (Table 1) and using the Chula formula $\{(height\ (cm): 10) + 4\}$. After TT was inserted into the subject airway, the TT length insertion evaluation using X-Ray based on the four radiographic criteria (Table 2). The evaluation of the TT length insertion accuracy was carried out by a different person (blind). Every evaluation of TT accuracy is performed by different operator.

Table 1. TT length insertion based on Colombian formula⁹

Height (cm)	OIL Female (cm)	OIL Male (cm)
145-159	19	19-20
160-174	20	20-21
175-189	21	21-22
>190	22	22-23

OIL: Optimal Insertion Length

Sample size calculation and Statistical analysis

The sample size was calculated based on the following formula:

$$n = \frac{N Z_{21-\alpha/2} P (1 - P)}{(N - 1) d^2 + N Z_{21-\alpha/2} P (1 - P)}$$

Where n is the minimum sample. $Z_{21-\alpha/2}$ (default normal distribution value (table Z) on an α -value)= 2.326; P

(proportion in population)= 2.8 % (0.028) obtain from literature, d (precision (corresponding to effect size) (absolut))= 0.075; N (total population in the ICU in the research period) = 117. Based in the calculation the minimal sample needed is 22 subjects. We add more subjects becoming 25 in each group. The total study subjects was 50.

The data obtained were displayed in mean and percentage. The data was statistically analyzed using the Chi-Square test and T-test SPSS version 18 (IMB Statistic, USA).

Table 2. TT length insertion accuracy criteria based on radiographic criteria¹¹

TT length insertion accuracy criteria
TT length insertion > 2 cm above the carina and > 2 cm below the vocal cords
TT insertion between the medial tip of the clavicle
TT located in the T3 or T4 vertebrae
TT is 3.4–5 cm above the tangent (from the lower aspect) of the aorta Knuckle

RESULT

The study was conducted on 50 adult patients who received mechanical ventilation with TT in the ICU. The demographic characteristics of the research subjects are shown in Table 3. Based on the homogeneity test, demographic characteristics of the subject, including age, height, weight, and gender of the Chula formula (n= 25) and Colombian formula (n= 25) groups having a p-value > 0.05. This shows that the demographic characteristics between the two groups are homogeneous.

Table 3. The demographic characteristics of the subjects

Characteristic	Groups				
	Chula formula (n=25)		Colombian formula (n=25)		p-value
Age (Mean ± SD)	4.68	± 19.47	44.2	± 14.8	
Height (Mean ± SD)	159.7	± 7.46	159.24	± 5.83	0.801
145-159 cm	16	(32%)	11	(22%)	0.265
160-174 cm	9	(18%)	13	(26%)	
175-189 cm	0	(0%)	1	(4%)	
Weight	1.28	± 15.73	57.16	± 8.06	0.250
Gender					1.000
Male	10	(20%)	10	(20%)	
Female	15	(30%)	15	(30%)	

p-value: homogeneity test, significant p>0.05

The radiographic characteristics used to determine the accuracy of the TT length insertion include the TT located > 2 cm above the carina and > 2 cm below the vocal cords, midway between the medial ends of the clavicle, in the position of the T3 or T4 vertebrae, and 3,4 –5 cm above tangent (from bottom aspect) of Knuckle aorta.

Based on the first characteristic, the length of TT insertion > 2 cm above the carina and > 2 cm below the carina, it is known that all subjects (n= 25) (50% of the population) of the Chula formula received TT with a precise depth. In the Colombian formula, 22 subjects (44.0% of the population) received TT with a

Table 4. The TT length insertion based on radiographic parameters

Radiographic parameters	Colombian formula		Chula formula		p-value	Chi-square
	Not Precise	Precise	Not Precise	Precise		
TT length insertion > 2 cm above the carina and > 2 cm below the vocal cords	3 (6.0%)	22 (44.0%)	0 (0%)	25 (50.0%)	0.074	3.191
TT insertion between the medial tip of the clavicle	13 (26.0%)	12 (24.0%)	4 (8.0%)	21 (42.0%)	0.007*	7.219
TT located in the T3 or T4 vertebrae	4 (8.0%)	12 (42.0%)	3 (6.0%)	22 (44.0%)	0.002*	9.191
TT is 3.4–5 cm above the tangent (from the lower aspect) of the aorta Knuckle	4 (8.0%)	21 (42.0%)	1 (2.0%)	24 (48.0%)	0.157	2.000

p-value: T-test, *)significant $p < 0.05$; the percentage is based on the total number of each group

precise depth of >2 cm above the carina and >2 cm below the carina. However, based on statistical tests, the two groups were not significantly different ($p = 0.074$). Based on radiographic characteristics, the TT insertion was right in the middle between the clavicle's medial ends; there was a significant difference between the two groups ($p = 0.007$). A total of 21 subjects in the Chula formula group (42.0% of the population) received a precise TT insertion. In the Colombian formula group, only 12 subjects (24.0% of the population) received TT with a depth of exactly midway between the medial ends of the clavicle (Table 4).

There was a significant difference between the Colombian formula and Chula formula groups in the radiographic parameters, the TT position right at T3 or T4 vertebrae ($p = 0.002$). Research subjects in the Chula formula group received more precise TT in the T3 or T4 vertebrae position ($n = 22, 44.0\%$) compared to the Colombian formula group ($n = 12, 24.0\%$) (Table 4).

The radiographic parameters of the TT depth's accuracy at 3.4–5 cm above the tangent (from the bottom aspect) of the knuckle aorta showed no significant difference between the Colombian formula and Chula formula groups ($p = 0.157$).

DISCUSSION

Based on radiographic characteristics (TT located in the T3 or T4 vertebrae and TT insertion between the clavicle's medial tip), the Chula formula significantly produces higher accuracy than the Colombian formula. This study supports research by Techavivate et al.¹² where the Chula formula (height formula) can be used for Asian populations. In that study, 99% of subjects who used the Chula formula confirmed that the TT tip was inserted at least 2 cm above the carina and the top end of the TT cuff remained at least 2 cm below the vocal cords. In our study, the Chula formula group had a higher precision of TT > 2 cm above the carina and > 2 cm below the vocal cords than the Colombian formula.

Base on some references, there is some variation in the Chula formula. Here are some formulas used for specific populations (Table 5). This formula display the different formula on the different ethnicity. This study uses the formula by Cherng et al.¹³, which is also used in the Thailand population. Thus, the Chula formula used in the Thai population also shows the same results in Indonesia's subjects. The research by Pang et al.¹⁴ stated that variations in height cause variations in the accuracy of the length of the TT insertion. In this study, the height formula (Chula formula) is still proven to be significant in producing the

appropriate depth in Indonesia's population of research subjects. The Chula formula technique is more significant than the Colombian formula technique because the subject's height has a relationship with the trachea's length. This study also supports the research of Mukherjee et al.⁶ explained that gender and weight did not affect determining the length of TT insertion. In this study, the combination of height and weight (Colombian formula) was no better than the height formula (Chula formula).

Table 5. Chula formula (height base formula) variation

Publication	Formula	Population
Cherng et al. 2005 ¹³	(4+ (height (cm)/10)	Thailand
Varshney et al. 2011 ⁹	((height (cm)/7)-2,5)	India
Gomez et al. 2016 ⁸	((height (cm)/5)-13)	South America

Although Chula formulas produce greater accuracy, several factors consider the increase in the risk of tracheal length changing. Female gender, extreme age (very young and elderly), short stature, post-surgical changes after pulmonary lobectomy surgery, and respiratory tract disease history are significant risk factors for shorter trachea length. Male gender, height, children/adults who are not elderly, disease status that increases vital capacity and residual volume, and possibly other lung diseases are all risk factors for increased trachea length.¹⁵

The limitation of this study was the number of research samples is relatively small because the research was conducted in only three months. Further studies regarding the estimation of the TT length insertion's accuracy can be carried out in various intubation procedures for patients undergoing elective surgery. Fiber Optic Bronchoscopy (FOB) can be used to evaluate the length of the TT insertion and to measure the length of the airway in adult patients. Changes in the position of the distal end of the TT during pre-intubation and the operation can occur when the patient changes the patient's position, such as the lateral position, prone position, Trendelenburg position.

CONCLUSION

In conclusion, Chula formula (height formula) significantly produces the higher accuracy of the TT length insertion in Indonesian patients who received mechanical ventilation than the Colombian formula (the combination of gender and height). This result should be beneficial in health facilities with insufficient chest x-ray, especially in the intensive care unit.

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CONFLICT OF INTEREST

The author declares there is no conflict of interest.

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