INDONESIAN JOURNAL OF ANESTHESIOLOGY AND REANIMATION
Volume 3 (2), July 2021 : 54-61

Original Article

ACCURACY COMPARISON OF ENDOTRACHEAL TUBE (ETT) PLACEMENT USING CHULA FORMULA WITH MANUBRIUM STERNAL JOINT (MSJ) FORMULA

Christya Lorena[1], **Hamzah**[1a], **Maulydia**[1]

[1] Department of Anesthesiology and Reanimation, Faculty of Medicine, Universitas Airlangga/Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

[a] Corresponding Author: hamzah@fk.unair.ac.id

ABSTRACT

Introduction: Intubation mistakes, such as ETT malposition, will result in serious complications. Endobronchial intubation can cause pneumothorax and contralateral lung collapse (atelectasis). On the contrary, superficial ETT could increase the risk of being released easily, leading to desaturation or even cardiac arrest. A shallow ETT position could cause the compression of the vocal cord and laryngeal nerve by ETT's cuff. An optimal position can be reached if the cuff position is 1.5-2.5 cm under the vocal cord and the tip is 3-5 cm above the carina. Several methods of ETT depth measurement based on airway length data can be an alternative, especially during the COVID-19 era, where the use of a stethoscope to check ETT depth is limited. **Objectives:** To analyze the accuracy of ETT depth placement using Chula and MSJ formula. **Methods and Material:** We conducted the prospective comparative analytic research on 50 patients who had elective surgery in GBPT operating room at Dr. Soetomo Hospital Surabaya. The research data during the intubation and FOL (Fyber Optic Laryngoscope) from each patient were height, MSJ length, initial ETT length, the distance of carina-ETT tip, the distance of cuff-vocal cord, and final ETT length. **Result and Discussion:** In the Chula formula group, the average patients' height was 160.60cm ± 9.738 for men and 157.76 cm ± 8.604 for women. The average MSJ length was 20.28 cm. The application of the Chula formula is more accurate because ETT revision was carried out in only 8.0% of the samples, with an average revision is 0.04. On the other hand, the ETT revision with an average of 0.868 on the MSJ formula group was conducted in 84% of the samples. This research also found a linear correlation between increasing ETT depth and body height. **Conclusion:** Applying the Chula formula to measure the ETT depth for Indonesian (Javanese) people is more appropriate than the MSJ formula.

Keywords: *Chula* formula; ETT depth accuracy; FOL (Fyber Optic Laryngoscope); *MSJ* Formula; Medicine

ABSTRAK

Introduksi: Kesalahan dalam intubasi, seperti malposisi ETT, akan mengakibatkan komplikasi yang serius. Intubasi endobronkial dapat menyebabkan pneumothoraks dan kolaps paru kontralateral (atelektasis). Sebaliknya, ETT yang terlalu dangkal meningkatkan risiko mudah terlepas, sehingga menyebabkan desaturasi sampai dengan *cardiac arrest*. Posisi ETT yang dangkal dapat menyebabkan kompresi pita suara dan saraf laringeus rekuren oleh balon ETT. Posisi optimal jika balon berada 1.5-2.5 cm di bawah pita suara dan ujung distal berada 3–5 cm di atas *carina*. Beberapa cara pengukuran kedalaman ETT berdasarkan data panjang jalan napas dapat menjadi alternatif terutama di era covid karena penggunaan stetoskop untuk pemeriksaan ETT menjadi terbatas. **Tujuan**: Penelitian ini menganalisis ketepatan penempatan kedalaman ETT menggunakan formula *Chula* dengan formula *MSJ*. **Bahan dan Metode:** Kami melakukan penelitian analitik komparatif prospektif pada 50 pasien yang mengikuti operasi elektif di kamar operasi GBPT RSUD Dr. Soetomo Surabaya. Data penelitian yang diambil pada masing-masing sampel saat tindakan intubasi dan FOL (*Fyber Optic Laryngoscope*), yaitu tinggi badan, panjang *MSJ*, panjang ETT awal, jarak *carina*-ujung ETT, jarak *cuff-vocal cord*, dan panjang ETT akhir. **Hasil dan Pembahasan:** Didapatkan rerata tinggi badan kelompok formula *Chula*, yaitu 160.60 cm ± 9.738 (laki-laki) dan 157.76 cm ± 8.604 (perempuan), serta rerata panjang *MSJ* 20.28 cm. Aplikasi formula *Chula* lebih akurat karena revisi ETT hanya dilakukan pada 8.0% sampel dengan rerata revisi 0.04. Sedangkan formula *MSJ*, revisi ETT dilakukan pada 84% sampel, dengan rerata revisi 0.868. Dalam penelitian ini juga ditemukan korelasi

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linier penambahan kedalaman ETT dengan penambahan tinggi badan. **Kesimpulan:** Penggunaan formula *Chula* untuk mengukur kedalaman ETT pada orang Indonesia (suku Jawa) lebih tepat dibandingkan formula *MSJ*.

Kata Kunci: Formula *Chula*; Ketepatan Kedalaman ETT; FOL (*Fyber Optic Laryngoscope*); Formula *MSJ*; Kedokteran

Article info: Received February 4th 2021, Received in Revised February 17th 2021, Accepted March 24th 2021

INTRODUCTION

Intubation is the gold standard to secure the airway. Endotracheal tube (ETT) ideal depth is the concern in securing the position of ETT. The malposition of ETT could cause serious complications. ASA research project reported that ETT malposition incidents are related to respiratory disorders in 2% of the adult population, and 85% of them suffered brain damage (1,2).

Deep ETT will touch the carina and stimulate sympathetic response and lead to tachycardia, hypertension, or bronchial spams. Endobronchial intubation also causes pneumothorax and contralateral lung collapse (atelectasis). In reverse, shallow ETT can increase the risk of ETT being detached, leading to desaturation to cardiac arrest. The superficial position of ETT can result in compression and trauma of vocal cords and laryngeal nerves by ETT's cuff (2,3). Ideal ETT position of the ETT cuff is 1.5-2.5 cm below the vocal cords, and the distal end of ETT is 3-5 cm above the carina (4).

Objectively, there are several methods of measuring the ETT depth based on airway length data. Research by Lee *et al*., (5) on population in Korea used the data to measure the upper incisor-MSJ distance with the head extension position. This study found a significant linear correlation with airway length that can be used to determine the ideal ETT depth. The correlation formula is {0.868 x (incisor-MSJ distance, head extension position) + 4.26}. While the ETT length was obtained by subtracting 3 cm from the MSJ formula (6).

Meanwhile, another measurement method, found in a study in Thailand in 2005, showed that body height correlates with the optimal depth of ETT. Based on this connection, the Chula formula was found ((height in cm: 10) + 4)). The study mentioned that the result of tip location was at least 3cm above the carina, which was confirmed by using FOB (4,7).

Examination by using FOB can provide a direct visualization to measure the accuracy of ETT depth (8,9). In this study, the use of FOB was also utilized to measure the actual ETT position, to determine the ETT's depth using the Chula formula compared to the MSJ formula (measuring the incisor-MSJ distance). These two measurements formula are alternative ways of determining the ETT depth individually (10).

MATERIALS AND METHODS

Research Design and Sample

This research is a prospective comparative analytic research on patients who had elective surgery in the GBPT operating room of Dr. Soetomo Academic Hospital, Surabaya, in November-December 2020. The Hospital Ethics Committee has approved this study. The sample collection technique was obtained from the study population that met the inclusion and exclusion criteria. In a total of 50 samples, all research subjects were randomly allocated into groups and received the same treatment.

This research's inclusion criteria are adult patients (age 18-65 years old) and PS ASA 1-2. The research method was explained to the

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guardian, and should they were willing to sign the informed consent, and the patient would be included as a research subject. The exclusion criteria are patients with anatomical defects in the face, neck, and upper airway; difficult airway sign, Mallampati 3-4, limited neck movement, history of cervical bone abnormalities and injuries, Trendelenburg position, BMI ≥ 30, abdominal distension, comorbid pulmonary disorders, and surgery in the airway area.

Data Collecting Methods

Initial data such as gender, age, height, MSJ length, BMI, and PPDS competency were recorded in datasheets. Then, parameters of ETT length, cuff-vocal cord distance, carina-ETT tip distance, and ETT revision will be recorded in datasheets for further analysis.

Statistical Analysis

The research distribution data was carried out by data normality test using the Shapiro-Wilk test. Normally distributed data were analyzed using an independent t-test, and abnormal distribution data were analyzed using the Mann-Whitney test. In contrast, the categorical data were analyzed by using the Chi-square test. Statistical analyses were performed by using the Statistical Package for the Social Science (SPSS) v19 software

RESULTS AND DISCUSSION

The research involved 50 adult patients with the same number of men and women, 25 samples (50%), and 25 samples (50%) perspectively. On age characteristics, the distribution was even in both research groups with an average age of 40. The two groups had normal BMI, and the distribution of the two groups was almost average, with the value of the Chula formula group was 23.15 ± 3.849, and the MSJ formula group was 23.09 ± 3.283.

Moreover, the height included in the Chula formula component was evenly distributed in both groups. The average height of both groups was 160.60 cm ± 9.738 for Chula and 157.76 cm ± 8.604 for the MSJ formula group. Besides, the average length of the MSJ group was 20.28 cm. The distribution of the study population and their demographic characteristic are detailed in table 1.

Table 1. Research Subject Demography

Demographic Data	Chula	MSJ	Percentage	P-value
Gender				
Male	13	12	50 %	0.777
Female	12	13	50 %	
Age				
18-25 yo	3	6	18.0 %	
26-35 yo	4	7	22.0 %	0.539
36-45 yo	7	4	22.0 %	
46-55 yo	7	5	24.0 %	
56-65 yo	3	3	14.0 %	
BMI	23.15± 3.849	23.09± 3.283	-	0.882
Height				
140-150 cm	5	4	18	
151-160 cm	8	12	20	0.720
161-170 cm	8	6	14	
> 170 cm	4	3	7	

Next, the initial ETT length difference was ± 1.18 cm shorter in the MSJ formula group. ETT revision that was carried out to the Chula formula group was 0.04, while the MSJ group was 0.868. By this result, it can be concluded that the ETT revision score between both groups was significantly different ($p<0.001$). The ETT analysis data will be displayed in table 2.

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Table 2. ETT Analysis Result

ETT length (cm)	Group		P-Value
	Chula (n=25)	MSJ (n=25)	
Initial ETT Median (Min-Max)	20.0 (18 – 21.5)	19.0 (17.5 – 21.5)	< 0.001
Final ETT Median (Min-Max)	20.0 (18.5 – 21.5)	19.5 (18.0 – 21.5)	0.088
ETT Revision Score Median (Min-Max)	0.0 (0.0 - 0.5)	1.0 (0.0 – 1.5)	< 0.001
ETT Average Length Mean ± Standard Deviation	20.16 ± 0.921	19.72 ± 0.867	0.084

Dominant height in this study was group height of 151-160 cm and 161-170 cm. There was a correlation between ETT depth and height that the increase in ETT length was in line with the increase of height. The analysis data will be shown in table 3.

Table 3. ETT Depth Analysis and Its Comparison with Height

Height (cm)	ETT Length Mean Median ± Standard Deviation	P-Value	r-Value
140 – 150 (n=9)	19.0 ± 0.546	<0.001	0.805
151 – 160 (n=20)	19.5 ± 0.343		
161 – 170 (n=14)	20.5 ± 0.385		
> 170 (n=7)	21.36 ± 0.244		
Total (n=50)	20.0 ± 0.913		

ETT position was confirmed by using FOB. The direct measurement from the carina-ETT tip and cuff-vocal cord distance were measured precisely. In both groups, we found the same problem occurred: the shallow ETT position with the distance of CF-VC < 1.5 cm. Only two samples needed revision in the Chula formula group, while the MSJ formula group had 21 samples that needed to be corrected because the ETT position was shallow. The analysis data of the ETT position will be shown in table 4.

Table 4. ETT Optimal Position Analysis

ETT Position	Chula (%)	MSJ (%)	P-Value
C-T Distance			
Shallow (< 3cm)	0 (0.0%)	2 (8.0%)	0.490
Precise (3-5 cm)	25 (100%)	23 (92%)	
Deep (>5 cm)	0 (0.0%)	0 (0.0%)	
CF-VC Distance			
Shallow (<1.5 cm)	2 (8%)	19 (76%)	
Precise (1.5-2.5 cm)	23 (92%)	5 (20%)	<0.001
Deep (>2.5 cm)	0 (0.0%)	1 (4%)	
Combined Distance			
Shallow C-T & Deep CF-VC	0 (0.0%)	1 (4%)	
Shallow C-T & Preicse CF-VC	0 (0%)	1 (4%)	
Precise C-T & Shallow CF-VC	2 (8%)	19 (76%)	<0.001
Precise C-T & Precise CF-VC	23 (92%)	4 (16%)	
ETT Revision	2 (8%)	21 (84%)	<0.001

The ETT cuff that we utilized in this research was 7.5 for men and 7.0 for women. The gender between the two study groups was evenly distributed with a p-value > 0.05; this is a coincidence because the samples were the population that met the inclusion and exclusion criteria regardless of their gender.

In the study of Mukherjee *et al.*, (9), the number of men was higher than women; however, this was not significant in the parameter test. Then, Lal *et al.*, (11)'s study found a correlation between ETT depth and

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height related to gender, yet it was not significant except in some extreme cases. Herway *et al*., (12) found a length difference of trachea, namely 0.7 cm longer for men. Research conducted by Fatma, (13) on body anthropometry found that men have a higher body posture than women.

The comparison of age characteristics between the two groups in this study was not significant. The average age was 40 years in this study, with the range of age was 18-65 years old. This study was conducted in patients age > 18 years old because airway anatomical structure involves the size of the head, nose, tongue, epiglottis, larynx, trachea, bronchus (14).

In addition, with that range of age, the criteria of mild-to-moderate- health condition (PS ASA 1 and 2) was easy to find. While in old age, the usually found condition are patients with severe illness (PS ASA > 2) or with the lung problem due to the lung physiology changes with age. PS ASA >2, thus it can shorten the apnea time when the ETT depth examination is carried out using FOL.

Based on geriatric anthropometry, men and women decreased by 2.7 cm and 4.22 respectively, usually associated with body posture, osteoporosis, spinal damage, and spinal abnormalities (kyphosis, scoliosis, and lordosis), affecting the height factor in measurement (13).

Another characteristic, which is obesity, can be a problem that complicates the laryngoscope intubation procedure because of huge anatomical changes in the face and neck due to the fat accumulation in that area. It is determined by body mass index (BMI). BMI value was evenly distributed between two formula groups ($p > 0.05$).

The research conducted by Busetto *et al*., (15) explained that there was no correlation between length changes in the pharyngeal area with BMI increase. However, in research by Lin et al., (16), a strong correlation was found between the increase of BMI and the increasing length of the hyoid area, which will explain that BMI affects the upper airway length. However, in the study by Varshney *et al*., (4), there was no correlation between BMI airway length.

This research uses a comparison of two formulas in determining ETT optimal depth. The first formula, the MSJ formula, introduced by Lee *et al*., (5), measures airway length based on the distance between incisors-MSJ (head extension). This formula is not correlated with height but with the airway size, which is based on the distance between the incisor-carina (head in neutral position) that was measured by using the FOB.

The other formula is the Chula formula, proposed by Techanivate *et al*., (7). This formula correlates the length of the airway with the height to determine the length of ETT to acquire precise depth according to the criteria, namely 3-5 cm above the carina and 1.5-2.5 cm below the vocal cords. Research by Lal *et al*., (11) also mentioned that the ETT depth would linearly increase with the individual height. Likewise, this study also found that the addition of ETT depth correlates with body height.

In the study, the height was evenly distributed between the two formula groups. The average height of men was 166.4 cm, and the average height of women was 151 cm. This result is similar to the study conducted by Techanivate *et al*., (7) in the Thai population. The average height of the men and women population was 166.1 cm and 156.1 cm,

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respectively; this is similar because both populations are Asian populations.

Further, both in these two studies, it was found that men are taller than women. This result can be due to the differences in posture and activity between them. According to the study by Fatma, (13), the body posture anthropometric measurement of adult men consistently higher than adult women, influenced by the hormonal and the stature of each gender.

Ronen *et al*., (17) stated that the height in those two genders is not much different before puberty, and it will be different after that. It affects the development of the upper airway, where men's will be longer than women's.

The fatal complications can result from the malposition of the ETT. Shallow ETT can result in spontaneous extubation of the head movements and cause irritation or trauma to the vocal cords, leading to irritation, inflammation, or vocal cord ischemia. Deep ETT can cause ETT to enter one lung, occurring oxygenation disorder, leading to atelectasis and pneumothorax (14,18).

Introduced by Lee *et al*., (5), the MSJ formula is based on the measurements between incisor-MSJ (head extension position), which is one way to measure ETT depth. This formula is formulated based on its correlation with the airway length (incisor-carina. Mukherjee *et al*., (9) conducted a study on the Indian population to support Lee's findings that the incisor-MSJ distance describes the airway length, although the correlation is not as strong as in Lee's study. Cherng *et al.,* (19) also found a correlation between sternal length and tracheal length, but not the incisor-carina length.

MSJ formula was found based on the calculation in the Korean population, which includes Asia as well, but when applied in this study, there was a significant difference, p< 0.001 (5). In this group, many ETT positions were found to be not ideal; there were 21 samples (84%) shallower in ETT depth, thus needed revision to obtain the right distance, ETT tip-carina 3-5 cm and cuff-vocal cord 1.5-2.5 cm (4,20).

In Lee *et al*., (5) research data, the Korean population's average height was higher than the Indonesian population, namely 171 cm for men and 158 cm for women. However, in this study, more shallow ETT positions were found.

On the other hand, the Chula formula was formulated using the height anatomical markers. Several studies also support the correlation between height and airway length, researched by Varshney *et al*., (4) with the Indian population and Gomez *et al*., (2) study in the Colombian population. They found the correlation of height with the airway length.

This research uses the Chula formula as the second formula to measure ETT depth, with mean ETT depth found was 20.62 cm for men and 19.2 cm for women. The result of this study are close with the results of Techanivate *et al*., (7) study in Thailand population with the mean length of men and women ware 20.8 cm and 19.6 cm. However, this result is much different from European ethnicity, which is in several studies found that the length of the ETT to be greater than the Asian population, namely 23 cm for men and 21 cm for women, which affected by the posture of Europeans, which is bigger and taller (11).

Inferencing the Chula and MSJ formula, which are both used in the Asian population, it can be concluded that the Chula formula by Techanivate *et al*., (7) is more relevant to the Indonesian population. The ideal ETT position was found more in the Chula formula group, namely 23 samples (92%) with precise C-T

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and CF-VC distance, while two samples (8%) with shallow CF-VC distances (< 1.5 cm) that require ETT revision. This research also found a correlation between body height and ETT depth, as in the Techanivate study.

CONCLUSION

The Chula formula is more accurate in determining the accuracy of the ETT depth for the Indonesian population than the MSJ formula. This research also found a correlation between the addition of ETT depth and the increase in body height.

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