

## ORIGINAL ARTICLE

## COMPARISON OF CHULA FORMULA WITH STANDARD 21/23 RULE FOR ESTIMATION OF OROTRACHEAL TUBE DEPTH IN INTUBATED ADULT PATIENTS: A SINDH INSTITUTE OF UROLOGY AND TRANSPLANTATION EXPERIENCE

Ramesh Kumar, Fakhir Raza Haidri, Heeralal, Bushra Zafar

Sindh Institute of Urology and Transplantation (SIUT), Karachi-Pakistan

**Background:** The proper estimation of depth of the orotracheal tube (OTT) in intubated patients is difficult. Several methods have been developed for proper estimation of the depth of OTT. The purpose of this study was to compare two commonly used formulae (21/23 rule and Chula formula) for proper estimation of depth of OTT in our Pakistani population. **Methods:** In this randomized interventional study, we included 74 adult patients. The study was conducted in the Intensive care unit of a tertiary care hospital in Karachi, Pakistan, from October 2021 to April 2022. Patients were intubated using either the 21/23 rule (OTT was fixed at 21 cm in females and 23 cm in males from the right incisor) or the Chula formula (OTT was fixed at the right incisor according to the height based formula,  $\{(height\ in\ cm/10)+4\}$ ). The distance between the carina and the OTT tip was measured using the digital chest x-ray with a PACS software. **Results:** A total of 74 patients were intubated in which 32 were intubated using 21/23 rule and 42 were intubated using the Chula formula. Four female patients in 21/23 rule group encountered unsafe distance between the carina and the tip of the OTT (i.e.,  $<2\ cm$ ) while no such complications were reported in Chula formula group ( $p$ -value 0.031). **Conclusion:** Chula formula was safe method for OTT placement in our study. Further studies with larger sample size are needed to assess the safety and efficacy of Chula formula for Pakistani Population.

**Keywords:** Critical care; Airway; Chula formula; 21/23 rule; Orotracheal intubation

**Citation:** Kumar R, Haidri FR, Heeralal, Zafar B. Comparison of chula formula with standard 21/23 rule for estimation of orotracheal tube depth in intubated adult patients: A Sindh institute of urology and transplantation experience. J Ayub Med Coll Abbottabad 2023;35(1):114-7.

DOI: 10.55519/JAMC-01-11237

### INTRODUCTION

Orotracheal intubation is a commonly performed procedure in the intensive care unit (ICU). Proper positioning of the orotracheal tube (OTT) in trachea of intubated patients is of paramount importance as too far advancement of the OTT in the right main bronchus may lead to volutrauma and barotrauma of the right lung and collapse of the left lung.<sup>1</sup> Tube placement more than five centimetres away from the carina may cause accidental extubation.<sup>2</sup>

The safe distance between the OTT tip and carina is 2–5 cm as flexion and extension of the neck move the OTT tip to the average length of 1.9 cm towards or away from the carina, respectively. This safe distance helps to protect against the complications of OTT displacement and reflects the proper depth of OTT in intubated patients.<sup>3</sup>

There are various methods to confirm the placement of the OTT in the trachea of intubated patients in the ICU. This includes bilateral chest auscultation, waveform capnography, and chest X-Ray. Bilateral chest auscultation misses 60% of

right main bronchus intubations and is not a reliable method to confirm the placement of the OTT in the trachea.<sup>4</sup> Waveform capnography is the gold standard method for confirmation of OTT in the trachea but it is not widely available and it does not tell the exact location of OTT in the trachea.<sup>5</sup> Chest x-ray is a commonly used modality to confirm the position of OTT in the trachea but it will not prevent the immediate complications of OTT placement.<sup>6,7</sup>

ICU physicians use several methods to estimate the proper depth of OTT to prevent OTT placement related complications prior to its confirmation with a chest X-Ray. These include 21/23 rule<sup>8,9</sup>, Chula formula<sup>10</sup>, 20/22 rule<sup>11</sup>, Indian formula<sup>12</sup>, Japanese formula<sup>13</sup>, topographic landmarks method<sup>14</sup>.

The famous 21/23 rule is a standard and widely used method across the globe to determine the proper depth of OTT in intubated patients. According to this rule, the OTT depth should be set at 21 cm in females and 23 cm in males from the right incisor.<sup>8,9</sup> It was studied in the western population (USA) and cannot be generalized as the length of the trachea may vary with the height of

the patient.<sup>15</sup> Moreover, height of the Western population differs from that of the Asian population, so the 21/23 rule needs to be verified in the Asian population.

On the other hand, the Chula formula  $\{(height\ in\ cm/10)+4\}$  was used in a study done by Techanivate A *et al.* which used the height of the patient for OTT depth estimation. It was studied on 100 Thai patients and had an accuracy of 99% in predicting the proper depth of OTT in intubated patients.<sup>10</sup>

Our literature review did not show with certainty whether the Chula formula or the 21/23 rule is appropriate in the Pakistani population to determine the proper depth of OTT. The aim of our study was to compare these two formulae for safe placement of OTT in the Pakistani population.

### MATERIAL AND METHODS

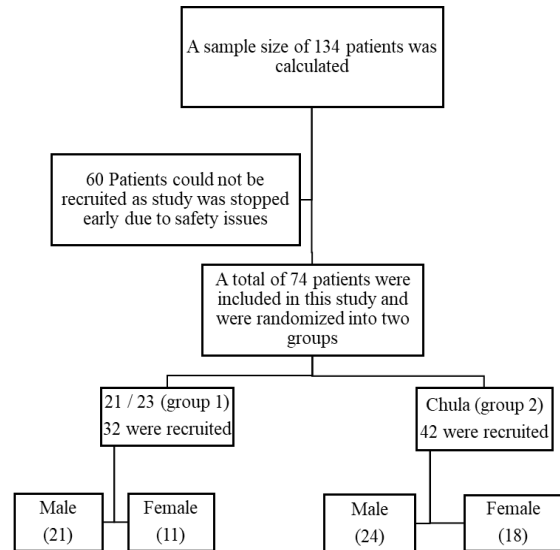
We conducted this randomized interventional study in the intensive care unit of Sindh Institute of Urology and Transplantation (SIUT) from October 2021 to April 2022. An IRB approval for the research proposal was taken from SIUT-Ethical Review Committee (SIUT-ERC), SIUT-ERC-2021/A-339).

The safe distance in our study was defined as the distance between the carina and the tip of the OTT of between 2–5 cm. The unsafe distance was the distance between the carina and the tip of the OTT of either less than 2 cm or more the 5 cm.

A sample size of 134 was calculated based on the previous estimate of overall mean distance between the tip of OTT and the carina in intubated patients with Chula formula of  $3.55 \pm 0.85\ cm^{10}$ , and  $4.35 \pm 1.8\ cm$  with 21/23 rule<sup>9</sup>, with power of 90% and 5% level of significance. But only 74 patients were included in the study because study was stopped earlier due to safety concerns as our four patients in group 1 had unsafe distance between the carina and the tip of the OTT. Two patients had right main bronchus intubation while remaining two patients had the distance between the carina and the tip OTT of less than 2 cm. None of them had any ventilator associated adverse event like pneumothorax or the collapse of the lung.

Patients of age  $\geq 18$  years, both males and females of different ethnicities needing orotracheal intubation in ICU were included. Those with denture issues and chest wall deformities were excluded from the study. After taking the written informed consent from the attendants, the patients were randomly divided into two groups. Randomization was done using random allocation software application. In group

1, patients were intubated using 21/23 rule, in which the orotracheal tube was fixed at 21 cm in females and 23 cm in males from the right incisor. In group 2, patients were intubated using the Chula formula i.e.,  $\{(height\ in\ cm/10)+4\}$  and OTT was fixed at right incisor. Height of the patients was measured from head to the sole of the feet using measuring tape while patient was lying supine on bed and pillow was removed from under the head. Orotracheal intubation was performed by an experienced anaesthetist. Bedside confirmation of OTT placement was done by bilateral chest auscultation and capnographic monitoring (graphical representation of the partial pressure of carbon dioxide in exhaled breath). Digital chest x-ray was taken in all patients within one hour of the intubation. Patient's head was kept in neutral position and OTT position at right incisor was re-confirmed while x-ray was being taken. The data was collected in *pro forma* and included age, gender, ethnicity, height of patient, depth of OTT at the right incisor, and the distance between the carina and the tip of the OTT which was measured on digital chest x-ray using PACS software.



**Figure-1: Enrolment and randomization of the patients**

The data was analyzed in SPSS version 22.0. Continuous variables such as age and height were expressed as mean $\pm$ SD., while the distances (from the carina to the tip of the OTT and the depth of the OTT at right incisor) were expressed as median (IQR). The age was compared using student's independent two sample "t" test.

The distance between the carina and the tip of the OTT and depth of OTT at the right incisor were compared by applying Mann-Whitney U test. Categorical

variables such as gender, ethnicity and safe/unsafe distance were expressed as number and frequency. Gender was compared using Chi-square test. The safe/unsafe distance was compared using Fisher's exact test. A *p*-value of <0.05 was considered significant.

**RESULTS**

Initially, our calculated sample size was 134 patients. While conducting the study, we observed significant complications in group 1 of the patient population. The study was terminated early due to safety concerns, when four patients had safety issues as mentioned in the methods. A total of 74 patients were included in this study. We included patients of different age groups ranging from 18–80 years; 60% were males, and the commonest ethnic group was Urdu speaking (40.5%), followed by Sindhi speaking (39.2%). The average height of all patients was 164.9±10.5 cm. The average height of female patients was 155.4±7.4 cm while male patients had an average height of 171±6.9 cm. Table-1 shows the baseline characteristics of patients.

Out of 74 patients, group 1 contained 32 (43.2%) patients, and group 2 had 42 (56.8%) patients. There was no difference of age, gender and height of the patients between the two groups. The distance between the tip of OTT and the carina was 2.9 cm (IQR: 2.3–3.4) in group 1, while it was 3.8 cm (IQR: 3.5–4.1) in group 2. It was statistically significant (*p*-value <0.001). The median depth of OTT fixed at the right incisor in group 1 was 23 cm (IQR: 21–23). It was significantly higher than in group 2 (*p*-value <0.001), where the median depth was 20.5 cm (IQR: 19.8–21.1).

Four patients in group 1 had an unsafe distance between the carina and the tip of OTT, i.e., <2 cm. Two patients had right main bronchus intubation, one patient had an OTT tip just at the level of the carina, and one had a distance of 1.63 cm between the carina and the tip of OTT. All these complications occurred in females with a height equal to or less than 150 cm. Table-2 describes the comparison between the two groups.

**Table-1. Baseline Characteristics of patients**

Parameters	Mean ± SD	Frequency (%)
<b>Age (years)</b>	74.6±15.6	
<b>Gender</b>		
Male		45 (60.8)
Female		29 (39.2)
<b>Ethnicity</b>		
Urdu speaking		30 (40.5)
Sindhi		29 (39.2)
Pathan		5 (6.8)
Baloch		5 (6.8)
Punjabi		4 (5.4)
Persian		1 (1.3)
<b>Height (cm)</b>	164.9±10.5	
Male	171.0±6.9	
Female	155.4±7.4	

**Table-2: Comparison of 21/23 rule and Chula formula**

Parameters	21/23 rule (n=32)	Chula formula (n=42)	<i>p</i> -value
<b>Age (years), mean ± SD</b>	48.2±16.7	47.2±14.9	0.787
<b>Gender, n (%)</b>			
Male	21 (65.6%)	24 (57.1%)	0.459
Female	11 (34.4%)	18 (42.9%)	
<b>Distance from Carina to tip of OTT (cm), median (IQR)</b>	2.9 (2.3–3.4)	3.8 (3.5–4.1)	<0.001*
<b>OTT depth at the right incisor (cm), median (IQR)</b>	23.0 (21.0–23.0)	20.5 (19.8–21.1)	<0.001*
Male	23 (23-23)	21.0 (20.5-21.8)	
Female	21 (21-21)	19.7 (19.0-20.2)	
<b>Safe distance*** (i.e., 2-5 cm), n (%)</b>	28 (87.5)	42 (100)	0.031**
<b>Unsafe distance*** (i.e., &lt;2 cm), n (%)</b>	4 (12.5)	0	
<b>Gender, n (%)</b>			
Male with safe distance	21 (100)	24 (100)	
Female with safe distance	7 (63.6)	18 (100)	
Male with unsafe distance	0	0	
Female with unsafe distance	4 (36.4)	0	

n: number of the patients; SD: standard deviation;

OTT: orotracheal tube; IQR: interquartile range

\**p*-value: Mann-Whitney U test; \*\**p*-value: fisher's exact test

\*\*\*safe/unsafe distance: The distance between the carina and the tip of the OTT

**DISCUSSION**

Since the invention of positive pressure ventilation and use of OTT, the confirmation of the proper depth of OTT in intubated patients have always remained a challenge. Several methods had been evolved, besides chest X-Ray to confirm the correct placement of OTT at bedside.

In this study, we compared two commonly used methods, (i.e., 21/23 rule and Chula formula) for safe OTT placement and investigated to find out which formula is more useful to use in the Pakistani population. Chula formula was used in 56.8% of the patients and all patients in this group achieved a safe distance (2–5 cm) between carina and tip of OTT. These findings are almost same as described in Technavate A *et al.* study where accuracy of Chula formula was 99% in Thailand population.<sup>10</sup> On the other hand, the 21/23 rule was used in 43.2% of the patients in our study, and 12.5% of patients experienced OTT placement-related complications. Patients who encountered complications were all females with a height equal to or less than 150 cm. The possible reason behind these complications can be the difference between the heights of United States population (from where the 21/23 rule was formulated) and our population. The average height of females was 162±3 cm in a study conducted by Owen RL *et al.*<sup>8</sup> which is significantly higher than the

group of patients in our study where the height of female patients was of  $155.4 \pm 7.4$  cm. The previous study conducted by Lal A *et al.* also showed high rate (12.4%) of unsafe distance between carina the tip of the OTT in Asian population (Indian, Chinese, Malay) when 21/23 rule was applied<sup>11</sup>, which is comparable to our study.

Interestingly, a female patient in group 2 (Chula formula) had a height of 138 cm but she still achieved a safe distance between the carina and the tip of OTT. In group 2, the OTT depth at right incisor on average was 19.2 cm in females and 21.2 cm in males, around 2 cm lower than the 21/23 rule. This emphasizes the importance of height-based formula to prevent OTT placement-related complications especially when patients with extremes of heights are intubated. Only one patient in group 2 had a distance of 5 cm from the carina to the tip of the OTT. Although It was within the range of safe distance the patient was at high risk of accidental extubation with the movements of the neck.

This is the first study to compare these two formulae to the best of our literature search. The Chula formula was found to be safe in our study population in both male and female patients.

The main limitation of our study was the sample size which could not be completed. The reason was identification of four patients in the unsafe distance category. Previous study by Lal A *et al.* did not mention any such data despite the high frequency (12.4%) of endobronchial intubation.<sup>11</sup>

## CONCLUSION

Based on the results of our study, Chula formula is an easy and safe method for OTT placement in the Pakistani population to minimize the placement related complications. We recommend using Chula formula in our population for safe practice. Readjustment of OTT position after chest X-Ray remains the standard of care in all cases.

## AUTHOR'S CONTRIBUTION

RK: conceptualization of study design, write up, literature search, data collection, data analysis, data interpretation. FRH: Writing up, Literature search,

data analysis, data interpretation. H: Data collection, Literature search. BZ: Data collection.

## REFERENCES

1. Al-Qahtani AS, Messahel FM, Ouda WO. Inadvertent endobronchial intubation: A sentinel event. Saudi J Anaesth 2012;6(3):259–62.
2. Thille AW, Harrois A, Schortgen F, Brun-Buisson C, Brochard L. Outcomes of extubation failure in medical intensive care unit patients. Crit Care Med 2011;39(12):2612–8.
3. Conrardy PA, Goodman LR, Lainge F, Singer MM. Alteration of endotracheal tube position. Flexion and extension of the neck. Crit Care Med 1976;4(1):8–12.
4. Brunel W, Coleman DL, Schwartz DE, Peper E, Cohen NH. Assessment of routine chest roentgenograms and the physical examination to confirm endotracheal tube position. Chest 1989;96(5):1043–5.
5. Grmec S. Comparison of three different methods to confirm tracheal tube placement in emergency intubation. Intensive Care Med 2002;28(6):701–4.
6. Gupta PK, Gupta K, Jain M, Garg T. Postprocedural chest radiograph: Impact on the management in critical care unit. Anesth Essays Res 2014;8(2):139–44.
7. Hossein-Nejad H, Payandemehr P, Bashiri SA, Nedai HH. Chest radiography after endotracheal tube placement: is it necessary or not? Am J Emerg Med 2013;31(8):1181–2.
8. Owen RL, Cheney FW. Endobronchial intubation: a preventable complication. Anesthesiology 1987;67(2):255–7.
9. Roberts JR, Spadafora M, Cone DC. Proper depth of placement of oral endotracheal tubes in adults prior to radiographic confirmation. Acad Emerg Med 1995;2(1):20–4.
10. Techanivate A, Kumwilaisak K, Samranrean S. Estimation of the Proper Length of Orotracheal Intubation by Chula Formula. J Med Assoc Thai 2005;88(12):1838–46.
11. Lal A, Pena ED, Sarcilla DJ, Perez PP, Wong JC, Khan FA. Ideal length of oral endotracheal tube for critically ill intubated patients in an Asian population: Comparison to current western standards. Cureus 2018;10(11):e3590.
12. Varshney M, Sharma K, Kumar R, Varshney PG. Appropriate depth of placement of oral endotracheal tube and its possible determinants in Indian adult patients. Indian J Anaesth 2011;55(5):488–93.
13. Yao K, Goto K, Nishimura A, Shimazu R, Tachikawa S, Iijima T. A formula for estimating the appropriate tube depth for intubation. Anesth Prog 2019;66(1):8–13.
14. Evron S, Weisenberg M, Harow E, Khazin V, Szmuk P, Gavish D, *et al.* Proper insertion depth of endotracheal tubes in adults by topographic landmarks measurements. J Clin Anesth 2007;19(1):15–9.
15. Cinar U, Halezeroglu S, Okur E, Inanici MA, Kayaoglu S. Tracheal length in adult human: the results of 100 autopsies. Int J Morphol 2016;34:232–6.

Submitted: August 14, 2022

Revised: November 04, 2022

Accepted: December 02, 2022

## Address for Correspondence:

Dr Ramesh Kumar, Sindh Institute of Urology and Transplantation, Karachi-Pakistan

Email: ccdrramesh@gmail.com