Upper Airway Dimensions in North Indian Population: A Possible Guide to Appropriate Length of Laryngoscope Blade

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Abstract

Background The use of adequate size of blade may help minimize failures of endotracheal intubation (ETI) in non–operating room (OR) settings which are usually done by non–anesthesia health care professionals (NAHP). Prospective study was done to assess the appropriate length of the laryngoscope blade for North Indian population.

Materials and Methods Upper incisor-to-vallecula (UI-V), lower incisor-to-vallecula (LI-V), and lower end of mandible to hyoid (M-H) distances were measured on routine computed tomography (CT) images of head and neck, done in the neuroradiology department in successive patients older than 11 years of age with normal airway structures.

Results A total of 126 patients, which included 53 females and 73 males with an average age of 34.5 years (range 14–67 years), formed the study group. UI-V of males and females were 7.35 $\pm$ 0.54 and 6.99 $\pm$ 0.51 cm, respectively, and the difference was significant. LI-V of males and females were 7.05 $\pm$ 0.51 and 6.66 $\pm$ 0.50 cm, respectively, and the difference was significant. M-H in males and females were 3.42 $\pm$ 0.63 and 3.59 $\pm$ 0.52 cm, respectively, and the difference was not significant. Open mouth CT in 11 patients revealed an average increase of 1.66 and 0.45 cm in UI-V and LI-V ($n = 11$), respectively, and 0.59 cm decrease in M-H ($n = 9$) which were significant.

Conclusion Upper airway dimensions of the population may be the used for selecting appropriate size of blade of laryngoscope for ETI in non-OR settings especially by NAHP.

Keywords
- laryngoscope blade size
- endotracheal intubation
- upper airway dimension
- laryngoscopy

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Introduction

Endotracheal intubation (ETI) is essential for many health care professionals other than anesthetists especially in intensive care units (ICU), where non–anesthesia health care professionals (NAHP) including paramedical staffs look after the patients.[1,2] Failure to perform successful ETI can sometimes result in patient death.[2,3] A lot of reports are available in the field of ETI which include types of laryngoscopes, shape of blades, factors related to difficult intubation, adult and pediatric intubations, and ETI by trainees versus experienced doctors.[1,4–10] Surprisingly, available literatures rarely mention the effect of patient factor to selection of blade as per their length. Mostly, "better to choose larger blade" and "preference based on his experience" are the statements by authors and no evidence is available to guide selection of blade size.[1,7,11–15] There are studies of anatomical measurements of European population for assessing difficult intubation and size of oropharyngeal airway selection, but no anatomical measurement data are available from North Indian or any other region specifically to predict size of laryngoscope blade required for intubation.[12,16,17] Time to successful tracheal intubation is significantly faster for experts than trainees.[10] We also feel that length of blade may not matter in case of experts, but in non–operating room (OR) settings such as ICU, high dependency unit, or rarely in general ward, this appears an important reason for ETI failures/ difficulty mainly because NAHP are not adequately experienced in ETI.[10] Most common feedback at our center after such events were inability to see the vocal cords and most of the time largest size of the blade was being used. At few occasions, authors (D.K.J., M.J., and A.A.) could find tip of the laryngoscope blade beyond the epiglottis in the esophagus which appears to be underreported in the literature.

We planned this prospective study to know the appropriate size of laryngoscope blade required for intubation by NAHP by evaluating upper airway dimensions on computed tomography (CT) images of patients. As the study was performed at a tertiary pubic health care institute of national capital, which caters populations from almost all parts of North India, findings may be applicable for North Indian population.

Materials and Methods

Routine CT of head and neck is done at neuroradiology department of a tertiary level public health care center for various diseases were evaluated prospectively from March 1 to 31, 2016.

Inclusion Criteria

Successive patients older than 11 years of age undergoing CT of head and neck for various diseases were included. Cutoff age of 11 years was decided because most of the upper airway structures develop before this age.[18]

Exclusion Criteria

Patients older than 11 years, edentulous patients, and those with disease, defect, or prior surgery affecting upper airway were excluded from the study.

Informed consents were taken from the patients or guardian (in cases where patients were younger than 18 years). The following three dimensions were planned to assess upper airway from ETI point of view (►**Fig. 1A**):

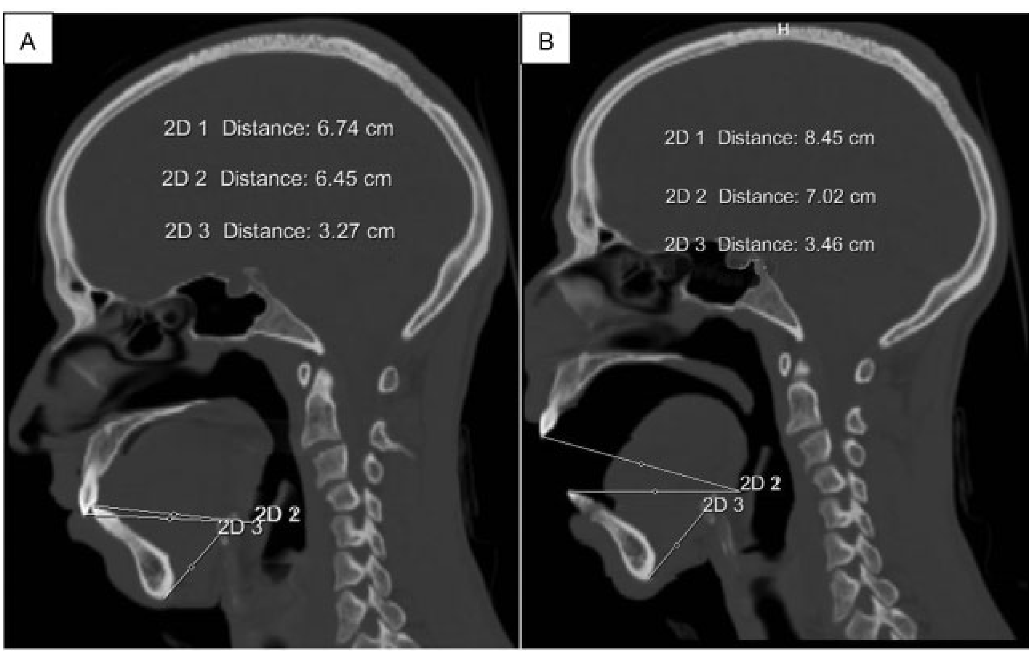

Fig. 1 Sagittal reconstructed CT images of head and neck with bone window settings show (A) closed and (B) open mouth upper airway dimensions UI-V (2D 1), LI-V (2D 2) and M-H (2D 3). CT, computed tomography; LI-V, lower incisor to vallecula; M-H, lower end of mandible to hyoid; UI-V, upper incisor to vallecula.

1. Upper incisor to vallecula (UI-V)
2. Lower incisor to vallecula (LI-V)
3. Lowermost surface of mandible to hyoid (M-H)

Spiral axial scanning of the head and neck was performed on successive patients older than 11 years of age with normal airway structures on a SOMATOM (Siemens, Munich, Germany) Emotion 16 Slice CT scanner in the neuroradiology department. Sagittal reconstruction of the data was performed and UI-V, LI-V, and lower end of M-H distances were measured on the midline sagittal CT images using standard tools (Syngo platform, Siemens Medical Solutions, Erlangen, Germany).

In addition to the closed mouth CT, open mouth CT was also planned in patients consenting for the additional study, to observe the changes in these dimensions (►**Fig. 1B**). All the images were collected separately and all the measurements were done simultaneously by three authors (D.K.J., R.K., and M.C.). Still images of two random patients in neurosurgery OR during ETI with Macintosh size 3 blade by each one of the two authors (M.J. and A.A.), who are experienced neuroanesthetists, were taken to observe contact point(s) or distance of different components of laryngoscope blade with the tip of upper and lower incisors (►**Figs. 2** and **3**).

Statistical Analysis

Mean and standard deviations were calculated for all the studied variables. Student *t*-test and paired *t*-test were applied for two independent samples and correlated samples, respectively. All analyses were done using PASW Statistics 18 software (SPSS Inc., Chicago, United States).

Results

A total of 126 eligible subjects with an average age of 34.48 ± 13.68 years were included in this study (►**Table 1**).

Fig. 3 Direct laryngoscopy during ETI in OR show upper and lower (not visible) incisors contact points over the laryngoscope blade (arrows). Anterior surface of the coupler (hook on base) of laryngoscope blade (arrow head) will limit insertion of blade beyond remaining usable length between incisor and coupler. ETI, endotracheal intubation; OR, operating room.

The mean age of the male subjects was 34.26 ± 12.94 years, whereas for female subjects, it was 34.77 ± 14.76 years. The average age was comparable for both the genders ($p > 0.05$). From ►**Table 2**, it can be seen that the mean UI-V length for male and female subjects were 7.35 ± 0.54 and 6.99 ± 0.51 cm, respectively, and it was significantly different for both the genders ($p < 0.001$). For male

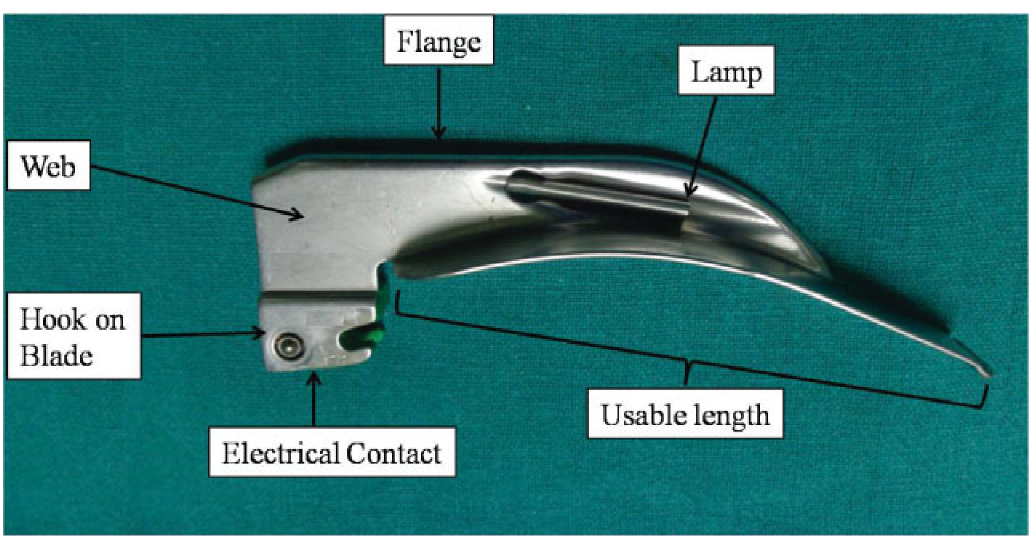

Fig. 2 Show parts of curved (Macintosh) type of laryngoscope blade used in North Indian hospitals in non-OR settings. OR, operating room.

Table 1 Patients ($n = 126$) with their age and airway dimensions

Variables	Mean ± SD ($n = 126$)
Age (y)	34.48 ± 13.68
UI-V (cm)	7.20 ± 0.55
LI-V (cm)	6.89 ± 0.54
M-H (cm)	3.50 ± 0.59

Abbreviations: LI-V, lower incisor to vallecula; M-H, lower end of mandible to hyoid; SD, standard deviation; UI-V, upper incisor to vallecula.

subjects, the average length of LI-V was 7.05 ± 0.51 cm and for female, it was 6.66 ± 0.50 cm, and LI-V length was significantly different for both the genders ($p < 0.001$), whereas no significant difference ($p > 0.05$) was observed for M-H length in males and females. M-H length could be measured in 124 patients, whereas in the remaining 2 patients, it could not be measured due to nonvisualization of lower end of mandible in the CT.

Out of 126 cases, 11 patients agreed to undergo open mouth CT of head and neck also, in addition to usual closed mouth CT, to assess effect of mouth opening on the three measurements (UI-V, LI-V, and M-H) (►**Table 3**). In 2 out of 11 patients, M-H could not be measured both in close and open mouth CT due to nonvisualization of the lower part of the mandible. Open mouth UI-V and LI-V in smaller group ($n = 11$) were 8.88 ± 0.79 and 6.50 ± 0.31 cm, respectively. Mouth opening ($n = 11$) led to increase in both UI-V (7.22 ± 0.44 cm) and LI-V (6.95 ± 0.44 cm) of 1.66 and 0.45 cm, respectively, and the changes in lengths by mouth opening were significant for both UI-V ($p < 0.001$) and LI-V ($p < 0.005$). In contrary to UI-V and LI-V, mouth opening led to significant ($p < 0.05$) decrease of 0.59 cm in M-H (3.92 ± 0.48 cm) ($n = 9$) (►**Table 3**).

Discussion

ETI in non-OR settings is usually done by NAHP and is more challenging.[1,2,19] MACOCHA score helps identify early in those patients in whom additional support is needed in case where ETI is required.[1,19] It has been reported that 25% of ETI done by paramedics NAHP in prehospital emergencies are misplaced leading to approximately 50% mortalities in the misplaced ETI group.[20] Training of NAHP involving ETI in manikins is considered inadequate and reports have suggested a minimum of 57 ETI in humans for training.[1,10,21] In non-OR settings, usually one type of laryngoscope (Macintosh in North Indian region), with different sizes of blades, is available.[5,12,22,23] The use of larger size of blade by NAHP, as usually done by experienced anesthetists, may lead to failure to manage airway, leading to catastrophic results, death or worse, brain damage.[1,24,25]

During laryngoscopy for ETI, upper incisor is in contact with the superior surface (flange) of the blade.[5,26,27] Tip of the blade depending on its type lies either anterior to vallecula or just posterior to the epiglottis.[12] Distance between UI-V therefore should be the length occupied by the laryngoscope blade. Further, it can be extrapolated that part of the blade longer than UI-V remains outside the upper incisor teeth, if tip of the blade is placed correctly.[22,23] The literature suggests that size 3 or 4 Macintosh blades are most commonly used in practice.[5] It has been suggested that even if no intension to insert its entire length, it is better to use size 4 English Macintosh, even in small insertion depths,

Table 2 Patients ($n = 126$) with their airway dimensions based on gender

Variable		Age (y)		UI-V (cm)		LI-V (cm)		M-H (cm)	
		Mean ± SD	*p*-Value	Mean ± SD	*p*-value	Mean ± SD	*p*-value	Mean ± SD	*p*-value
Gender	Male ($n = 73$)	34.26 ± 12.94	> 0.05	7.35 ± 0.54	< 0.001	7.05 ± 0.51	< 0.001	3.42 ± 0.63	> 0.05
	Female ($n = 53$)	34.77 ± 14.76		6.99 ± 0.51		6.66 ± 0.50		3.59 ± 0.52	

Abbreviations: LI-V, lower incisor to vallecula; M-H, lower end of mandible to hyoid; SD, standard deviation; UI-V, upper incisor to vallecula.

Table 3 Patients ($n = 11$) showing airway dimensions in closed and open mouth CT

Variables (number of patients)		Mean ± SD (cm)	*p*-Value
UI-V ($n = 11$)	Closed mouth	7.22 ± 0.44	< 0.001
	Open mouth	8.88 ± 0.79	
LI-V ($n = 11$)	Closed mouth	6.95 ± 0.44	< 0.05
	Open mouth	6.50 ± 0.31	
M-H ($n = 9$)	Closed mouth	3.92 ± 0.48	< 0.05
	Open mouth	3.33 ± 0.31	

Abbreviations: CT, computed tomography; LI-V, lower incisor to vallecula; M-H, lower end of mandible to hyoid; SD, standard deviation; UI-V, upper incisor to vallecula.

compared with the size 3 English Macintosh and the size 3 standard Macintosh.[5] Marks et al[12] selected European population for anatomic measurements based on X-ray laryngoscopy and highlighted that such measurements are population specific and should be done in other populations also. Most of the recommendations available are from the western world and there is no similar study available in Indian or Asian subcontinent which may guide us to select of appropriate blade size in our population, especially by NAHP with less experience of ETI.[12,17]

During normal laryngoscopy, mouth tends to close around the blade at the time of epiglottic elevation and visualization of the glottis.[12,28] An index of difficult intubation based on the amount of space available behind the mandible shows a highly significant correlation with degree of difficulty.[29] M-H distance in our study group may be helpful in evaluation of difficulty expected, which, though not analyzed in the current report, is a part of an ongoing larger study to predict ideal laryngoscope blade size and difficulties in ETI in North Indian population. Marks et al[12] studied upper incisor to hyoid length (IT) to analyze eyeline displacements and space available for tongue to be displaced during laryngoscope insertion using different types of blades. "IT" in the study by Marks et al ranged from 9.5 to 14.5 cm which will be little less than UI-V measured in our study, as vallecula is behind the hyoid. Open mouth CT in smaller group of 11 patients in our study revealed the UI-V of 8.88 $\pm$ 0.79 cm which is less than the study by Marks et al. Our study highlights the morphometric differences in the upper airway dimensions of European and North Indian population. It has been shown by Miller[30] that Macintosh blade 2 is better than larger blades (3 and 4) if "IT" is 8 cm or less. Furthermore, for "IT" more than 9 cm, larger blades (3 and 4) are superior to smaller one (size 2). Though there is no mention of ideal blade size for "IT" between 8 and 9 cm, sizes 2 and 3 blades should be ideal for these lengths. As "IT" will be slightly less than corresponding UI-V in the same patient due to reason mentioned earlier, size 2 blade of Macintosh or equivalent length of other laryngoscope blade should be ideal for most of the North Indian adult population. Open mouth CT could not be done in all patients of our study population due to unwillingness of the patients to avoid unnecessary exposures to radiation, which was a limitation. We are carrying out our study which may help us to substantiate our preliminary findings.

Macintosh remarked on two occasions that "the precise shape or curve of the blade does not seem to matter much provided the tip does not go beyond the epiglottis."[22,23] The curve of the Macintosh blade was designed with the intention of positioning the tip "into the angle made by the epiglottis with the base of the tongue."[23] The concern of blade tip going beyond the epiglottis was already highlighted by Macintosh, which was one of the common mistakes committed by NAHP at our institute, observed by the authors. We feel that blade tip going beyond epiglottis is underreported in the literature mainly because it does not occur with the experienced anesthetists.

ETI in the prehospital setting and inhospital but outside the OR shows a higher frequency of adverse events and a higher risk of mortality than similar events in OR.[31–33] In experience, poor assistance and an unfavorable environment may combine leading to a failure to optimize conditions.[34] Wrong size blade selection too is one of the various reasons for failure to manage airway.[34] Using specific blade in certain circumstances is felt to be very advantageous by some but not all authorities.[5,7,8,11] It has been felt that length of the blade should be sufficient to ensure that tip of the blade reaches the base of the vallecula to facilitate optimal elevation of the epiglottis. Need to carry out similar studies in different population groups are required to find out most common size of blade in that particular region. It may not be required for experienced anesthetists but is certainly required for NAHP because these are the people who most commonly manage airways of patients in prehospital and non-OR settings.

Smaller UI-V in females than males was a significant finding in our study; further indicates that female patients should be intubated using smaller blade of laryngoscope. LI-V distance may be important as inferior surface of laryngoscope blade (usable length), though not used as lever, but touches the upper end of lower incisor[27] (►**Fig. 2**). Inferior surface of the blade is limited posteriorly by the anterior surface of the coupler (hook on base) of the laryngoscope blade and lower incisor may limit advancement of the blade if it is shorter in length.[27] (►**Fig. 2**) LI-V may therefore guide us to know lower limit of the blade length. Width of the coupler (hook on base) of the standard Macintosh blade is 2.5 cm, which causes inferior surface of the blade 2.5 cm shorter than the superior surface (flange).[27] As per our study, inferior surface of the blade should not be less than 6.5 $\pm$ 0.31 cm (open mouth LI-V). Shorter open mouth M-H distance in males than females has not been reported earlier. It was an interesting finding because it indirectly indicates that ETI should be easier in females than in males due to more retromandibular space.[5,28,29]

Our preliminary conclusions are:

1. Length of the laryngoscope blade for ETI should be selected based on upper airway dimensions of the population especially by NAHP in non-OR settings.
2. Incisor-to-vallecula distance measurements in North Indian population appear to indicate that size 2 or 3 blade of Macintosh laryngoscope or equivalent length of other laryngoscope blade will be appropriate for ETI of adults especially if done by NAHP in non-OR settings.
3. Smaller size of the laryngoscope blade for ETI in females may be considered to minimize risk of failed ETI by NAHP in non-OR settings. ETI in female patients appear to be easier than males due to more retromandibular space.

Contribution of Authors

Deepak K. Jha, MCh: study concept, design, and article preparation. Anil Thakur, MS: literature research, analysis, and discussion. Chandra B. Tripathi, PhD: statistical analysis and results. Mukul Jain, MD:

literature research, photographs, study design, and article editing. Rima Kumari, MD: radiological study, measurement, and article editing. Monali Chaturvedi, MD: radiological study and data analysis. Arvind Arya, MD: literature research and concept.

The article has been reviewed and approved by all the authors for submission in the journal for publication.

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