



Influence of operating table height on laryngeal view during direct laryngoscopy: A randomized prospective crossover trial



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ABSTRACT

Background: Operating table height/patient level in relation to anaesthesiologist influences mask ventilation, laryngoscopy, intubation and task performance in terms of physical and mental workload. The same was evaluated in this study.

Methods: Twenty five specialist anaesthesiologists performed mask ventilation and laryngoscopy thrice and intubation once on six patients each, [n = 150] at three different operating table levels (Level X: patient at level of xiphisternum of anaesthesiologist, level A: 5 cms above; level B: 5 cms below xiphisternum). Primary variable was quality of laryngoscopic view obtained. Secondary variables were anaesthesiologist's comfort, ease of performing these tasks and movements at various joints in anaesthesiologist assessed in subjective and objective ways.

Results: Laryngoscopic view was best at levels X and A when compared to B ($p = 0.0004$). Mask ventilation was most comfortable at level B and least at level A ($p < 0.01$). At level B, there was maximum discomfort in 76.6% during laryngoscopy and 60% during intubation ($p < 0.001$). Level A had the fastest time (mean \pm SD) for both laryngoscopy (8.30s) and intubation (18.3s) ($p < 0.01$). Total joint movements were maximal at level B ($p < 0.001$).

Conclusion: Higher operating table levels are ideal for laryngoscopy and intubation whereas lower levels favour mask ventilation.

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1. Introduction

Endotracheal intubation being the most definitive means of securing an airway is facilitated by direct laryngoscopy. It is imperative to perform the same in minimum possible time to avoid fatal complications. This is achieved by proper positioning of the patient to obtain a good glottic view [1]. Only a few studies are available on the influence of operating table height/level of the patient on laryngeal view in relation to the anaesthesiologist [2]. The level also influences the task performance of anaesthesiologist in terms of physical and mental workload [3,4]. For ideal laryngoscopy and intubation, it is recommended to place the patient's forehead at the level of anaesthesiologist's xiphoid process, minimizing their back and neck movements during the procedure [5]. As there is insufficient scientific literature to support the same, a study was aimed to evaluate the quality of laryngeal view

(primary variable) in addition to ease of intubation and comfort of the anaesthesiologist (secondary variables) associated with three different table levels during mask ventilation, direct laryngoscopy and tracheal intubation while maintaining the patient factors identical. The hypothesis was that quality of laryngeal view would be better and comfortable at higher levels.

2. Methods

This study was approved by Institutional Ethics Committee of Kasturba Hospital, Manipal (IEC 543/2014) and was registered on Clinical Trials Registry of India. CTRI no: CTRI/2017/03/008123 [Registered on: 16/03/2017].

2.1. Study population

150 patients undergoing elective surgery requiring general anaesthesia with tracheal intubation were enrolled for the study after obtaining a written informed consent. (202 were assessed for eligibility, 17 were ineligible and 35 did not consent to participate,

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Fig. 1). They were further divided into three groups of 50 patients as per randomisation. Twenty-five specialist anaesthesiologists who had performed more than 1000 successful endotracheal intubations earlier were enrolled into the study on a voluntary basis. Every anaesthesiologist performed mask ventilation, laryngoscopy and intubation on 6 patients each at three different operating table levels. Inclusion criteria for patients were: age between 18 and 60 years of either gender, American Society of Anaesthesiologists of physical status I and II and BMI of 18–25 kg/m². Patients with difficult airway [6], loose teeth, edentulous jaw and those not meeting the inclusion criteria were excluded from the study.

On the day prior to surgery, airway was assessed through measurement of inter-incisor distance, thyromental distance, neck circumference and Mallampati classification [7,8]. Intraoperatively, patients were placed in supine position with a 6 cm pillow under their occiput facilitating flexion of the cervical spine. The initial table level was positioned according to either of the groups as described below. Standard monitoring included non-invasive arterial pressure measurement, peripheral oxygen saturation and electrocardiography. After pre-oxygenation for 3 min, anaesthesia was induced with i. v. propofol (2.5–3.0 mg kg⁻¹) and fentanyl (1.5–2 µg kg⁻¹). Neuromuscular blockade achieved with vecuronium bromide (0.1 mg kg⁻¹mg) and manual ventilation was provided through mask. Anaesthesia maintained with 1.5%–2% isoflurane in oxygen and air.

The three levels of operating table at which mask ventilation, laryngoscopy and intubation performed were:

- (i) **Level A**- Table with patient's forehead at the level 5 cms above anaesthesiologist's xiphoid process.
- (ii) **Level X** - Patient's forehead at the level of xiphoid process.
- (iii) **Level B** - Patient's forehead 5 cms below xiphoid process.

The study population (patients) was divided and allocated as per randomisation into one of the three groups according to the level at which tracheal intubation was performed.

- (i) **Group A**: Initial position of operating table at level B for first mask ventilation and laryngoscopy. After this, table was placed at level X for subsequent/second mask ventilation for 1 min followed by second laryngoscopy. Lastly table was brought to level A for final/third mask ventilation and laryngoscopy which was followed by intubation of the trachea.

- (ii) **Group B**: Initial mask ventilation and laryngoscopy at level A. Second mask ventilation and laryngoscopy at level X. Final level at B where tracheal intubation was performed.
- (iii) **Group X**: Initial table level at B. Subsequent level at A and final laryngoscopy and intubation at level X.

Hence, laryngoscopy was done at all three levels (n = 150) and intubation performed only once in the final level (n = 50) in any particular group. In between each laryngoscopy attempts, mask ventilation was executed for 1 min and anaesthesia maintained with isoflurane and oxygen as described above. Laryngoscopy was accomplished using Macintosh curved blades of size 3 or size 4 and trachea intubated with a cuffed PVC (polyvinyl chloride) endotracheal tube (Portex Ltd., UK) of size 7.0 mm and 8.0 mm internal diameter (ID) for females and males respectively.

The anaesthesiologist was not allowed any postural adjustment with regard to the following joints (flexion or extension of the neck, lower back, knee or ankle) during mask ventilation and was directed to take the neutral standing position. But adjustment was allowed during laryngoscopy or intubation. If mask ventilation was inadequate, airway adjuncts like oropharyngeal airway were allowed, but further inability or inadequacy to ventilate the patient would lead to exclusion of subject from the study.

2.2. Outcome measures

Laryngoscopic view: It was graded according to Cormack Lehane criteria: Grade 1, visualization of the entire laryngeal system; Grade 2, visualization of only the posterior portion of the laryngeal aperture; Grade 3, visualization of only the epiglottis; and Grade 4, non-visualization of the epiglottis [9]. Each time laryngoscopy was performed, view was recorded both before and after external laryngeal manipulation (ELM). Time taken for first laryngoscopy was noted. Subsequently the table was moved to level A, B or X in accordance to the group allocated. Laryngoscopy was repeated in other 2 positions with documentations of time taken and best laryngoscopic view with and without ELM.

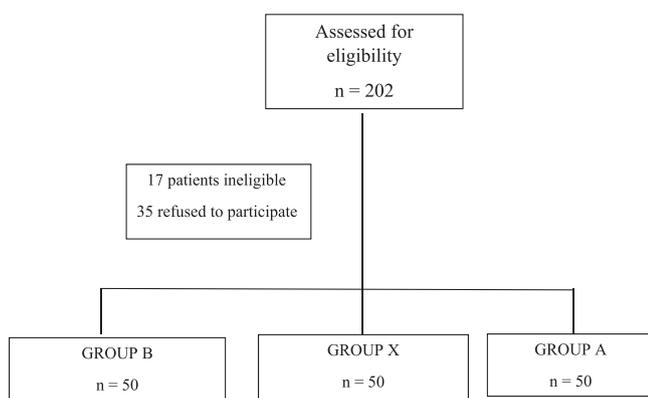
Laryngoscopy time: Started from introduction of the laryngoscope blade into the oral cavity and ended when best laryngoscopic view was obtained. **Intubation time:** Started from visualization of glottis till confirmation of intubation by waveform capnography. **Total intubation time:** It was the combination of laryngoscopy and intubation times.

Degree of discomfort during various tasks was assessed according to the following:

Mask ventilation: Subjectively where the anaesthesiologist graded the discomfort as absent, mild, moderate or severe.

Laryngoscopy: Subjectively as described above and objectively by an observer who looked for presence or absence of movements at various joints in the anaesthesiologist (neck, lower back, ankle and knee). Absence of movement was given a score of 0 and presence of movement scored 1 for each joint. Thus, the minimum score of 0 and a maximum score of 4 could be given to a particular patient.

Intubation: Subjectively as mentioned above, objectively through joint movements and also by Intubation difficulty score (IDS) [10]. IDS is a function of seven parameters (N₁–N₇), quantified numerically by the operator or an independent observer immediately after intubation. N₁ = Every additional attempt adds 1 point. N₂ = Each additional operator adds 1 point. N₃ = Each alternative technique adds 1 point. N₄ = Cormack Lehane grade (in number) minus 1. N₅ = Increased lifting force required adds 1 point. N₆ = Laryngeal pressure applied adds 1 point. N₇ = Vocal cord adduction adds 1 point. Thus IDS is the sum of all scores (0 = easy, 1–5 = slight difficulty, >5 = moderate to major difficulty).



Consort Flowchart

Fig. 1. Consort flowchart.

Table 1
Patient characteristics. Continuous data is expressed as mean (standard deviation), whereas categorical variables are presented as number of patients. ($p = 0.1$).

Group	B	X	A
Age in years	38.29 (12.069)	40.85 (12.273)	39.22 (12.203)
Height in cm	160.5 (6.188)	160.65 (5.685)	159 (6.036)
Weight in kg	57.69 (7.825)	59.46 (6.291)	59.36 (7.312)
Body Mass Index in kg m^{-2}	22.32 (2.082)	23.01 (1.828)	23.39 (1.606)
Gender (Male/Female)	31/19	19/31	27/23

The Observer was a junior resident in Anaesthesiology who documented various parameters including time and postural changes of anaesthesiologist.

These parameters/endpoint categories for reporting were chosen based on published reports [11,12].

Unanticipated difficulty in laryngoscopy and intubation warranted use of maximum laryngeal lifting force, styleted endotracheal tube, bougie or other alternatives according to anaesthesiologist's preference. If intubation was unsuccessful in two attempts, third attempt was made by another senior anaesthesiologist and patient excluded from the study. If the third attempt failed, a laryngeal mask airway was used. Decision to proceed with surgery or to awaken patient was left to discretion of consulting anaesthesiologist in charge. All patients received intravenous dexamethasone 8 mg after intubation to prevent possible sore throat as a result of repeated laryngoscopies.

2.3. Statistical methods

Sample size was calculated to be 150 based on 95% confidence level with a power of 80% and for an α -error of 0.05. Continuous variables (age, body weight, BMI, and duration of laryngoscopy and intubation) were expressed as the mean [standard deviation (SD)] and were compared using the analysis of variance. Categorical variables were presented as absolute values and were compared using chi square test. A p -value of 0.05 or less was considered statistically significant. The p -values of multiple comparisons were corrected by the Bonferroni method. Statistical analyses were performed using SPSS 18.0 for Windows (SPSS, South Asia, Bangalore).

3. Results

A total of 202 patients were enrolled in the study of which 17 were ineligible and 35 patients refused to participate. The 150 patients were divided into three groups namely groups A, X and B. Patient characteristics were similar between the three groups. ($p = 0.1$, Table 1).

Mask ventilation had maximum discomfort at level A with 86% (129/150) (mild, moderate or severe discomfort) and level B had no

discomfort in 89.3%. However B had discomfort in 76.6% during laryngoscopy and 60% during intubation ($p < 0.001$, Table 2).

Laryngoscopic view with and without ELM was best in Level X (CL grade 1 in 112 and 99 patients respectively). Level B was worse than level X by 15.3% (23 patients) without ELM ($p = 0.0004$) and 12.6% (19 patients) with ELM ($p = 0.037$). Level A was better than level X by 2.6% (4) and worse by 4.6% (7), whereas level B was worse than level X by 12.6% (19) with ELM ($p = 0.037$, Table 3).

Time taken for Laryngoscopy and Intubation were faster at higher table levels (X and A, X>A) when compared to B ($p < 0.01$, Table 2). There was no difference among the groups with relation to IDS ($p = 0.66$, Table 2).

Neck movements during laryngoscopy and intubation were nearly absent at level A and present in 100% at level B ($p < 0.001$, Table 4) Movements at the back and knee were also maximally found only at level B ($p < 0.001$). With respect to total movements, level B showed movements in two or more joints in 99.3% (149/150) during laryngoscopy and 98% (49/50) during intubation ($p < 0.001$). Level A had no movement at any joint in 54% (81) during laryngoscopy and 58% (29) during intubation (Table 4).

4. Discussion

Successful and swift direct laryngoscopy with tracheal intubation depends on attaining a line of sight from patients' maxillary teeth to larynx so that the oro-pharyngo-laryngeal axes fall in a straight line [13]. To attain this, proper positioning of patient's head and the level of patient in relation to the anaesthesiologist is vital.

Our study found that laryngeal view with or without ELM was best at higher table levels (X and A, X>A) when compared to B (Table 2). In contrast to our findings, a study reported no difference in views at different levels, but only when anaesthesiologists were allowed body adjustments. However, when body movements were

Table 3
Laryngoscopic view with and without external laryngeal manoeuvre (ELM).

Laryngoscopic view	Without ELM (n = 150)			p value	With ELM (n = 150)			p value
	B	X [#]	A [#]		B	X [#]	A [#]	
Cormack Lehane grade								
1	79	99	95	<0.01	97	112	110	<0.01
2	67	48	53		51	38	39	
3	4	3	2		2	0	1	
Laryngoscopic view	Without ELM		p value	With ELM		p value		
	A	B*		A	B**			
= X	135	125		139	129			
Worse than X	9	23	0.0004	7	19	0.037		
Better than X	6	2		4	2			

Chi square test [#] $p < 0.01$ vs B, * $p = 0.0004$ vs level X, ** $p = 0.037$ vs level X.

Table 2
Degree of task discomfort during mask ventilation, laryngoscopy and intubation, time taken for laryngoscopy and intubation, Intubation Difficulty Score at various levels.

Level	B	X	A	p value
Discomfort during Mask Ventilation ^a (1/2/3/4) n = 150	134/15/1/0*	102/48/0/0*	21/98/28/3	<0.001
Discomfort during Laryngoscopy ^a (1/2/3/4) n = 150	35/72/40/3	139/8/3/0 [#]	95/46/8/1 [#]	<0.001
Discomfort during Intubation ^a (1/2/3/4) n = 150	20/18/10/2	48/2/0/0 [#]	30/17/3/0 [#]	<0.001
Intubation Difficulty Scores ^a (0/2/3) n = 50	29/19/2	32/18/0	28/20/2	0.66
Time taken for Laryngoscopy(L) Mean \pm Standard Deviation ^b (in seconds)	10.52 \pm 3.37	8.43 \pm 2.51**	8.30 \pm 2.63**	<0.01
Intubation time(L) ^b Mean \pm Standard Deviation (in seconds)	24.04 \pm 6.34	18.62 \pm 5.38**	18.3 \pm 3.52**	<0.01
Total time for intubation ^b (L+I)	33.7 \pm 8.5	27.2 \pm 5.97**	26.4 \pm 4.36**	<0.01
Mean \pm Standard Deviation (in Seconds)				

Discomfort grades: 1-Absent, 2-Mild, 3- Moderate, 4-Severe. * $p < 0.001$ vs level A, [#] $p < 0.001$ vs level B, ** $p < 0.01$ vs level B.

^a Chi square test.

^b Repeated measures ANOVA.

Table 4

Movements of neck, lower back, knee, ankle and total movements in the anaesthesiologists during laryngoscopy and intubation.

Movement	Laryngoscopy (n = 150)			p value	Intubation (n = 50)			p value
	B	X	A		B	X	A	
Neck (absent/present)	0/150*	6/144*	149/1		0/50*	3/47*	50/0	
Lower Back (absent/present)	1/149	131/19 [#]	148/2 [#]		1/49	39/11 [#]	50/0 [#]	
Knee (absent/present)	78/72	150/0 [#]	147/3 [#]	<0.001	30/20	50/0 [#]	50/0 [#]	<0.001
Ankle (absent/present)	138/12*	150/0*	82/68		47/3*	49/1*	29/21	
Number of joints involved (Total number of movements) (0,1,2,3,4)	0,1,74,66,9	6/125/19/0/0 [‡]	81/65/3/1/0 [‡]		0/1/28/19/2	2/31/11/0/0 [‡]	29/21/0/0/0 [‡]	

Chi square test * $p < 0.001$ vs level A, [#] $p < 0.001$ vs level B, [‡] $p < 0.001$ vs level B (where two or more joints involved).

not allowed and erect posture was adopted, view was found to be better at higher levels [5], correlating with our results. A different study also found no change in laryngeal view and attributed this finding for not using POGO score (percentage of glottic opening score) for grading the laryngeal view [2], as POGO score was reported to have better reliability than Cormack-Lehane grading system [14]. But our study applied CL grading and still found the laryngeal view to be better at higher levels suggesting that irrespective of the method used for assessment, higher table levels provide better laryngeal views especially when laryngoscopists maintain neutral position without adjustments in posture.

With respect to time taken for laryngoscopy and intubation, the difference between the groups was noteworthy, with higher levels having quicker time. Although the largest mean difference between the groups appeared trivial with 2.2s for laryngoscopy, 5.74s for intubation and 7.3s for total time (Table 3), this minimal delay of few seconds may substantially influence the outcome of securing an airway in certain emergency situations (e.g. rapid sequence induction/pregnant women/children) [6]. It was reported elsewhere that the time taken for tracheal introducer placement in manikins was minimally affected by different patient levels with the largest mean difference of 2 s between the levels, thus correlating with few of our results [2].

It is well understood that anaesthesiologists tend to adopt poor postures during various procedures with movements at various joints affecting them [2]. The table height was further documented to influence task performance as well as physical and mental workload [3,4]. Cervical disc problems also have been reported due to poor posture [15,16]. Based on these reports and clinical experience, we hypothesized that higher table levels reduce the discomfort during laryngoscopy and tracheal intubation by limiting the need to bend the neck or lower back [5]. Accordingly our study witnessed comfortable laryngoscopy and intubation at higher levels (X and A) with respect to perception of difficulty by anaesthesiologists (Table 2). Also when comfort was assessed with regard to movements at various joints, neck movements were nearly absent in all at level A and almost present in all at levels B and X suggesting level A to be the ideal level with respect to neck movements. With respect to movements at the back, levels A and X (A>X) were found to be the ideal levels as A and X had no movements in nearly all and B had movements in almost all patients. It was also found that more joints were involved at lower levels both during laryngoscopy and intubation (Table 4).

A report stated inexperienced anaesthesiologists had more movements in their upper body to compensate for trolley height during laryngoscopy as compared to experienced anaesthesiologists who maintained their erect posture [17]. In contrast, our study involving specialist anaesthesiologists had more movements in the neck.

Level B was most comfortable for mask ventilation (89.3% having no difficulty) but difficult for laryngoscopy and intubation correlating with the findings of other studies [2,5]. Higher levels (A and X) were least comfortable for mask ventilation probably

because postural adjustments at neck, back, knee and ankle were not allowed for which anaesthesiologists compensated by creating uncomfortable angles at the joints of wrists, elbows and shoulders leading to discomfort.

This study had 100% success rate for tracheal intubation at all levels. Anaesthesiologists had no difficulty for intubation in most patients at either levels with regard to IDS (Table 2, $p = 0.66$). This was probably due to exclusion of patients with difficult airway and inclusion of specialist anaesthesiologists.

The strength of our study was in performing laryngoscopy at three different levels in the same patient. This was intended for attaining better data quality when compared to performing the same at different levels in different patients which was done in other studies where it was as well reported as a limitation [5]. Our results too were subject to following limitations which could possibly have resulted from an attempt to reduce the complexity of the study. Firstly, the laryngeal views were recorded based on the opinion of anaesthesiologist performing laryngoscopy rather than other blinded investigator. Secondly, assessment of joint movements were also based on the opinion of observer in terms of its presence and absence. Thirdly, degree of joint movements were not quantified. Fourthly, anaesthesiologist could not be blinded to different table levels. These limitations could be considered while designing future studies.

Hence it may be concluded that, higher operating table levels favour laryngoscopy and tracheal intubation and lower levels facilitate effortless mask ventilation. Also, in situations where repeated alterations in operating table height is not practical and these procedures (mask ventilation, laryngoscopy, intubation) needs to be performed at one level, the best possible level could be placing the patient at the level of xiphisternum of the anaesthesiologist where laryngoscopic view is best, intubation is faster and mask ventilation is relatively comfortable. Appropriate table height may also improve the likelihood of successful management of difficult airway by improving anaesthesiologist's perception of ease of intubation. In addition, it is imperative to seriously consider the occupational hazard due to poor posture and its consequences, however trivial it may appear and hence, posture needs to be emphasised while teaching the trainee anaesthesiologists.

Conflicts of interest

No conflicts of interests declared.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.tacc.2019.08.003>.

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