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Original Article

Anaesthesia Section

Comparison of Reverse and Normal Curve Techniques for ILMA-assisted Tracheal Intubation in Adult Patients: A Prospective Interventional Study

RASHMI PAL[1], HARSHITA DUTTA PRAJAPATI[2], RAVI BARDE[3], VIJENDER SINGH THAKUR[4]

ABSTRACT

Introduction: Securing airway is the main task of Anaesthesiologist. Intubating Laryngeal Mask Airway (ILMA) was made to simplify blind intubation. Still the outcome can vary with orientation of endotracheal tube.

Aim: To observe and compare the Normal Curve (NC) and Reverse Curve (RC) techniques of intubation through ILMA in adult patients with respect to success rate, intubation time, haemodynamic changes, and complications.

Materials and Methods: The present prospective interventional study was done in the Department of Anaesthesiology, MGM Medical College and MY Hospital, Indore, Madhya Pradesh, India. A total of 128 adult patients American Society of Anaesthesiologists (ASA) I and II, aged 18-60 years, undergoing elective surgery under general anaesthesia were included in the study. Patients were divided into two groups, NC and RC according to orientation of endotracheal tube through ILMA. Demographic data, number of attempts, time taken for successful intubation, Heart Rate (HR), mean arterial pressue, SpO_2 and postoperative complications were recorded. Statistical analysis was done with unpaired t-test and Chi-square test, $p<0.05$ considered significant.

Results: Baseline profile like age, sex, ASA, Mallampati and weight were comparable in both groups. Intubation success was 100% in first attempt. Intubation time was longer in NC (86.9±4.9 s) than RC (76.5±6.7 s, $p<0.001$). HR and MAP showed slightly higher trend in NC but not significant. SpO_2 stayed above 99% in all. Sore throat was more in NC (12.5% vs 4.7%) while hoarseness was rare and equal (1.6%).

Conclusion: Both NC and RC gave full success for intubation. RC was faster and had less sore throat. Hoarseness was rare and equal. RC may be better choice when quick intubation and less airway irritation is desired. Larger studies are needed to confirm in wider group of patients.

Keywords: Airway management, Haemodynamics, Laryngoscopy, Postoperative complications, Tracheal intubation

INTRODUCTION

Airway management is the main duty of Anaesthesiologist. It can be done with facemask, supraglottic airway or endotracheal intubation. Endotracheal tube gives best protection against aspiration but direct laryngoscopy needs training and equipment and also causes sympathetic stress with rise in HR and blood pressure [1]. Supraglottic airway devices are now very useful as they are easy to insert, and have high success and less sympathetic response [2].

The laryngeal mask airway is the most popular supraglottic device with near 100% success in operation theatre [3]. ILMA Fastrach is a modification which allows blind or fibreoptic intubation. It is valuable in cases where neck movement must be avoided like cervical spine surgery and has been compared with video laryngoscope [4]. ILMA is also accepted as bridge and rescue device in difficult airway in both adult and paediatric [2,3].

For intubation through ILMA two techniques are used. In NC the tube follows ILMA curvature. In RC the tube is rotated 180° opposite and then advanced. With NC, tube often stuck at vocal cord or push epiglottis. RC directs tip better to glottis and passes easy [5-7].

Previous studies have reported improved first attempt success and reduced intubation time with alternative orientations or devices [5,6]. But most works till now compared ILMA with other devices like video or direct laryngoscope [2,4,6]. Evidence comparing NC and RC orientations in adults remain limited highlighting the need for further evaluation [5-7]. The present study aimed to observe and compare the normal and RC techniques of intubation through ILMA in adult patients, focusing on success rate, intubation time, haemodynamic changes and postoperative complications.

MATERIALS AND METHODS

The present prospective interventional study was conducted in the Department of Anaesthesiology, MGM Medical College and MY Hospital, Indore, Madhya Pradesh, India. The study was carried out over 12 months, from September 2022 to August 2023. A total of 128 adult patients aged between 18 and 60 years, belonging to ASA physical status I-II, were included. Ethical clearance was obtained from the Institutional Ethics Committee (IEC number - EC/MGM/Sept-22/46), and written informed consent was taken from all participants before enrolment.

Sample size calculation: Sample size was calculated using G*Power software version 3.1.9.2. Based on previous studies that reported significant differences in LMA insertion success rates between Fentanyl-Propofol and Fentanyl-Etomidate combinations, a larger cohort was chosen for improved power. For 95% confidence level and 80% power, with effect size=0.5 (moderate), the minimum required sample was 128 (64 per group). This exceeded the 60-patient sample sizes used by Chhatrapati S et al., and Manjunath P et al., ensuring more robust statistical significance [5,7]. The formula used was:

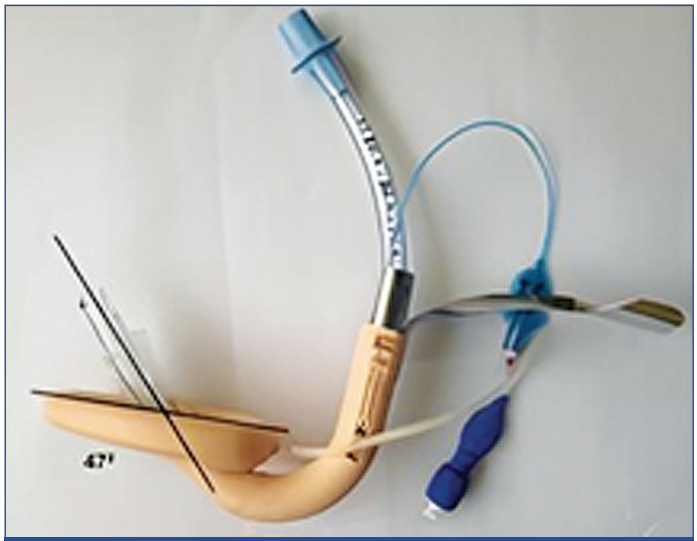
$$n=2(Z\alpha/_2+Z\beta)^2\ \sigma^2/\delta^2$$

Inclusion and Exclusion criteria: Adult patients aged 18-60 years of either sex, ASA physical status I-II, scheduled for elective surgeries under general anaesthesia needing endotracheal intubation were included. Patients with mouth opening less than 2 cm, Mallampati class III-IV, oropharyngeal/laryngeal pathology, aspiration risk, pregnancy, Gastroesophageal Reflux Disease (GERD), hiatus hernia, peptic ulcer disease, morbid obesity or those requiring more than

three intubation attempts were excluded. A total of 128 patients fulfilled all eligibility criteria and were enrolled (64 in each) others were excluded during screening.

Study Procedure

Patients were divided into two groups based on tube orientation through the ILMA: Group NC (NC along the 90° curvature of ILMA) and Group RC (RC opposite to the ILMA curvature). The two orientations differed in the angle of tube emergence the RC showing a shallower exit angle of about 20° aligning better with the glottic opening for smoother passage and less impingement and the NC demonstrated a steeper angle of nearly 47° leading to more anterior impingement against the epiglottis during blind intubation [Table/Fig-1,2]. Standard intraoperative monitoring was applied, including Electrocardiogram (ECG), pulse oximetry, capnography and non-invasive blood pressure. Premedication included glycopyrrolate 0.02 mg/kg and midazolam 0.03 mg/kg. Anaesthesia induction was done with propofol 2 mg/kg and fentanyl 2 µg/kg, followed by atracurium 0.5 mg/kg and sevoflurane (2-4%). ILMA size 3 or 4 was used according to weight, with appropriate Endotracheal Tube (ETT) size (6.5 or 7.0 mm ID). Intubation attempt was defined as failure if tube could not pass, if no capnograph trace was seen, or if SpO_2 fell below 90%. A maximum of three attempts were allowed, after which direct laryngoscopy was performed. Patients HR, Mean Arterial Pressure (MAP) and oxygen saturation were monitored continuously and values were noted before induction, before device insertion, after device insertion after 1st ventilation and five minutes after 1st ventilation. Postoperative sore throat was assessed at 24 hours using a Visual Analog Scale (VAS) (0-10) with score >3 considered positive [8]. Postoperative pain was not assessed in this study.



[Table/Fig-1]: Normal Curve (NC) orientation of endotracheal tube through Intubating Laryngeal Mask Airway (ILMA).

[Table/Fig-2]: Reverse Curve (RC) orientation of endotracheal tube through Intubating Laryngeal Mask Airway (ILMA).

STATISTICAL ANALYSIS

Data were entered in a computer database and analysed using Statistical Package for Social Sciences (SPSS) version 22.0. Normality of distribution was tested, and quantitative variables were expressed as mean±SD. Between group comparisons were done with unpaired t-test or Mann-Whitney test as applicable. Categorical variables were compared with Chi-square test. A p-value <0.05 was considered statistically significant.

RESULTS

The demographic profile in [Table/Fig-3] includes age distribution, sex ratio, body weight, ASA grade, and Mallampati classification was well balanced across the two groups. This ensured comparability and minimised baseline bias, as none of these factors showed any significant intergroup difference.

Parameters	NC (n=64)	RC (n=64)
Age (years)	42.1±9.6	43.0±10.2
Weight (kg)	61.28±5.34	60.28±4.80
Sex (M/F)	14/50	18/46
ASA grade (I/II)	53/11	44/20
Mallampati (I/II)	48/16	53/11

[Table/Fig-3]: Demographic and baseline data of study groups.

The HR responses at different peri-intubation stages showed a slightly higher trend in the NC group, but the differences never reached statistical significance as seen in [Table/Fig-4]. This indicates that both techniques produced similar haemodynamic stability with respect to HR.

Duration	NC	RC	t-test	p-value
Before induction	87.23±10.349	83.89±9.840	1.873	0.063
Before device insertion	84.16±10.423	80.73±9.890	1.905	0.059
After device insertion	92.66±9.447	90.36±8.456	1.449	0.150
After 1st ventilation	84.47±9.935	80.92±11.417	1.875	0.063
5-min after 1st ventilation	86.38±10.712	86.36±9.619	0.009	0.993

[Table/Fig-4]: Comparison of Heart Rate (HR) between Normal Curve (NC) and Reverse Curve (RC) group.
Values are expressed as Mean±Standard Deviation. Statistical analysis was performed using the unpaired student's t-test

MAP values presented in [Table/Fig-5] fluctuated marginally after device insertion and ventilation, yet the overall pattern remained comparable between NC and RC groups. The absence of significant variation suggests that both methods are equally safe in maintaining blood pressure during the intubation process.

Duration	NC	RC	t-test	p-value
Before induction	87.58±6.096	87.98±4.633	-0.419	0.676
Before device insertion	87.43±5.477	85.69±4.704	1.927	0.056
After device insertion	85.40±5.113	84.57±4.362	0.986	0.326
After 1st ventilation	84.50±4.634	84.17±4.410	0.404	0.687
5-min after 1st ventilation	90.09±4.374	89.25±4.457	1.080	0.282

[Table/Fig-5]: Comparison of Mean Arterial Pressure (MAP) between Normal (NC) and Reverse Curve (RC) group.
MAP values are presented as Mean±SD. Comparison between NC and RC groups was conducted using the unpaired student's t-test

Oxygen saturation was consistently well maintained in both groups throughout all stages of induction and intubation. The values remained above 99% in all patients as in [Table/Fig-6] confirming that adequate oxygenation was not compromised by either technique.

Both the techniques ensured universal first-attempt success but reverse orientation offered a clear advantage by reducing intubation time [Table/Fig-7]. Postoperative throat discomfort showed a tendency to be lower with reverse orientation, while hoarseness remained rare and identical across groups.

Duration	NC	RC	t-test	p-value
Before induction	99.86±0.393	99.89±0.403	0.444	0.658
Before device insertion	99.88±0.454	99.91±0.387	0.419	0.676
After device insertion	99.89±0.362	99.91±0.387	0.236	0.814
After 1st ventilation	99.89±0.403	99.92±0.324	0.483	0.630
5-min after 1st ventilation	99.88±0.418	99.89±0.403	0.215	0.830

[Table/Fig-6]: Comparison of SpO_2 between normal and Reverse Curve (RC) group.
Oxygen saturation (SpO_2) values are given as Mean±SD. Inter-group comparison used unpaired Student's t-test

Parameters	NC (n=64)	RC (n=64)	p-value
Number of attempts=1	64/64 (100%)	64/64 (100%)	–
Time taken for intubation (sec)	86.92±4.961	76.50±6.693	<0.001
Sore throat (VAS >3 at 24 h)	8/64 (12.5%)	3/64 (4.7%)	0.115
Hoarseness	1/64 (1.6%)	1/64 (1.6%)	1.000

[Table/Fig-7]: Comparison of number of attempts, time taken for intubation and post op complications between groups.
Categorical variables are expressed as n/N (%). Continuous variable (time taken for intubation) is Mean±SD. Statistical comparisons were using Chi-square test for categorical variables and unpaired t-test for continuous variables

[Table/Fig-8] shows the association between postoperative complications and study groups. Sore throat occurred more in the NC group (12.5%) compared to the RC group (4.7%), but the difference was not statistically significant (p=0.115). Hoarseness was seen in one patient (1.6%) in each group with no significant difference (p=1.000). This indicates that both orientations were comparable in terms of postoperative airway morbidity.

Parameters	NC (n=64)	RC (n=64)	χ^2 value	p-value
Sore throat (VAS >3 at 24 h)	8 (12.5%)	3 (4.7%)	2.47	0.115
Hoarseness	1 (1.6%)	1 (1.6%)	0.00	1.000

[Table/Fig-8]: Chi-square analysis for association of postoperative complications between Normal Curve (NC) and Reverse Curve (RC) groups.
Chi-square test applied; p-value <0.05 considered statistically significant

DISCUSSION

The present study looked at NC and RC technique of ILMA intubation in adult surgical patients. Baseline profile like age, sex, ASA grade, Mallampati and body weight were almost same in both groups which minimised the risk of baseline bias influencing outcomes. This allowed for a more accurate interpretation of differences attributable to intubation techniques alone. Intubation was successful in all patients where first attempt only showing 100% rate. This again shows ILMA is reliable for blind intubation in routine airway cases. Similar reports exists by Chhatrapati S et al., who showed full success in both NC and RC with little better in reverse [7]. Manjunath P et al., noted that 100% in standard and 96.7% in reverse yet one needed crossover [5]. Krishna H et al., using CTrach also found almost equal success in both techniques [9]. Taken together these studies support ILMA as highly effective which matches the present observations.

Assis MLM et al., also concluded that ILMA (Fastrach type) remains superior in terms of blind intubation success compared to i-gel or Air-Q, particularly when used with reinforced ETTs [10]. Girish K et al., similarly reported higher intubation success with LMA Blockbuster (91.4%) than Air-Q ILA (55.7%) among adults undergoing elective surgery [11]. These results further strengthen the present study findings showing ILMA's consistent high success rate across studies.

A key distinction was intubation time which was significantly shorter with RC orientation compared to NC (76.50±6.7 vs 86.92±4.9 sec with a p<0.001). This highlights the advantage of reverse orientation in facilitating smoother tube passage. Previous reports support this trend. Chhatrapati S et al., had noted slightly shorter mean intubation times with reverse orientation although not statistically significant [7]. Manjunath P et al., found occasional prolongation with reverse orientation, while Pavani K et al., reported intubation times between 12-14 seconds with no major intergroup difference [5,6]. The relatively longer times observed in the current study compared to earlier trials may be explained by differences in operator protocol and the definition of intubation time. The consistent observation of reduced time with RC orientation emphasises its practical utility. Anatomical rationale further supports this finding: the angle of tube emergence through ILMA is steeper with NC (47°) and shallower with RC (20°) leading to better alignment with the glottic opening and fewer episodes of impingement as described by Brain [12].

Nazir N et al., observed similar improvement in insertion efficiency with LMA Blockbuster compared to i-gel, attributing it to better curvature and reduced tube impingement [13]. Their findings correspond with the observation of the authors that a reverse orientation or improved anatomical curvature simplifies the glottic alignment and reduces intubation time. No significant differences were reported in intubation times between ILMA and other devices when fiberoptic guidance was used suggesting operator experience may offset design advantages [10,11,13].

Haemodynamic responses in both groups were stable with only mild and non-significant increases in HR and MAP, particularly in the NC group. These results suggest that both orientations are equally safe with respect to cardiovascular changes. Previous works echo this stability. Manjunath P et al., Chhatrapati S et al., and Sarkar J et al., showed ILMA-guided intubation produced modest haemodynamic fluctuations compared with direct laryngoscopy [5,7,14]. Jarineshin H et al., had confirmed that ILMA insertion evokes a lower pressor response and Mishra S et al., Reported a smoother haemodynamic profiles compared to conventional laryngoscopy [15,16]. Oxygen saturation stayed above 99% in both NC and RC across all stages with no fall and no difference. This shows oxygenation is preserved regardless of orientation. Similar results were shown by Chhatrapati S et al., where SpO_2 remained stable in both groups without desaturation [7]. Pavani K et al., also reported SpO_2 always >98% during intubation with either orientation using CTrach, again proving ILMA maintains oxygenation well [6].

In line with this study findings Assis MLM and Girish K et al., also reported minimal haemodynamic variability with ILMA use in comparison to direct laryngoscopy or Air-Q devices, suggesting its favourable safety profile for patients with cardiovascular vulnerability [10,11].

Postoperative sore throat was low was low. Sore throat was more with NC (12.5%) compared to RC (4.7%) though not significant. Lin GW et al., reported sore throat around 13.2% with LMA, Mohan M et al., showed 8-14% [17,18]. Michalek P et al., in their review noted 5-20% [19]. Present NC values fit this range while RC clearly had fewer complaints likely due to smoother tube passage. Hoarseness was only 1.6% in each group, close to the 1-5% frequency in earlier reports. Overall both NC and RC are safe and effective but RC offers shorter time and less sore throat with same haemodynamic and oxygen stability. This supports RC as a more practical option for adult airway management. Nazir N et al., similarly had showed lower postoperative sore throat with LMA Blockbuster compared to i-gel and Air-Q supporting our results that better-curved airways reduce mucosal irritation and laryngeal trauma [13].

Overall both NC and RC are safe and effective, but RC offers shorter time and less throat with same haemodynamic and oxygen stability. The present study's findings are thus in agreement with major systematic reviews and recent RCTs supporting ILMA and its modified orientations as optimal blind intubation conduits in adult airway management [10,11,13]. This supports RC as a more practical option for adult airway management.

Recent correspondence by Bhardwaj M et al., highlighted that reverse (180° rotation) techniques in supraglottic devices like the

LMA Protector can significantly improve first-attempt success and reduce tongue folding during insertion, without added airway trauma. They emphasised the need for randomised trials to validate the technique across devices and patient groups [20]. Future studies should therefore aim to compare RC orientation with other rotation techniques (90°-180°), use video-assisted ILMA guidance and evaluate 3D-modeled curvature optimisation in both elective and emergency scenarios [20,21].

Limitation(s)

The present study was conducted in a single centre which may restrict the generalisability of the findings. All intubations were performed by experienced Anaesthesiologists; outcomes may vary with residents or less trained providers. Fiberoptic confirmation of tube position was not undertaken, and long-term complications were not evaluated. Larger multicentre trials, including varied patient populations and operators of different experience levels, are required. Comparative studies with newer supraglottic devices, video-assisted techniques, and cost-benefit analyses across healthcare settings would be valuable. Extended postoperative follow-up may also provide better insight into the true incidence of airway morbidity.

CONCLUSION(S)

The RC technique of endotracheal tube insertion through ILMA achieved the same first-attempt success as the NC but required significantly less time indicating smoother passage and better alignment. Postoperative sore throat was less frequent with RC, while hoarseness remained rare and equal in both groups. Haemodynamic stability and oxygenation were comparable, confirming safety of both techniques. RC may thus be considered a simple and effective alternative, though larger multicentre studies are needed before universal recommendation.

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PARTICULARS OF CONTRIBUTORS:
1. Professor, Department of Anaesthesiology, MGM Medical College, Indore, Madhya Pradesh, India.
2. Junior Resident, Department of Anaesthesiology, MGM Medical College, Indore, Madhya Pradesh, India.
3. Assistant Professor, Department of Anaesthesiology, MGM Medical College, Indore, Madhya Pradesh, India.
4. Junior Resident, Department of Anaesthesiology, MGM Medical College, Indore, Madhya Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Harshita Dutta Prajapati,
Junior Resident, Department of Anaesthesiology, MGM Medical College,
Indore-452001, Madhya Pradesh, India.
E-mail: h.dutta151995@gmail.com

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