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An evaluation of retrograde light-guided laryngoscopic intubation and its comparison with conventional direct laryngoscopic intubation

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ABSTRACT

Background: Conventional Direct Laryngoscopic (DL) tracheal intubation requires certain amount of skill for its successful outcome. To improve the success of intubation, various alternatives to conventional laryngoscopy have been described in recent years. Retrograde Light-Guided Laryngoscopy (RLGL) is a recently described technique for endotracheal intubation. **Methods:** A prospective randomized study was conducted in 100 patients, randomly intubated according to a computer generated procedure using either DL or RLGL by a single operator. The primary outcome was the success rate of tracheal intubation. The parameters evaluated were: success rate of tracheal intubation, time to glottic exposure and time to tracheal intubation, Cormack and Lehane grades, haemodynamic parameters and post operative sore-throat and hoarseness of voice. **Results:** Compared with DL, the overall success rate was greater in the RLGL group ($P = 0.004$). This was associated with a shorter time to glottic exposure [4.0(±1.09) vs 4.72±(1.16) sec, $P = 0.001$], shorter intubation time [5.28(±1.34) vs 6.10(±1.22) sec, $P < 0.001$]. The laryngoscopic grades using RLGL were better than using DL ($p = 0.002$). The haemodynamic responses were comparable in both the groups. There was decreased incidence of sore-throat ($p = 0.083$) and hoarseness (0.005) at 24 hrs with RLGL compared to DL. **Conclusions:** RLGL is an alternative approach for intubation. We conclude that the RLGL is a safe and effective device for achieving endotracheal intubation in normotensive adults with normal airways.

Key words: Airway, Endotracheal Intubation, Retrograde Light-Guided Laryngoscopy

INTRODUCTION

Conventional Direct Laryngoscopic tracheal intubation is an effective technique for airway protection during anaesthesia and various critical scenarios. As we all know that conventional Direct Laryngoscopic tracheal intubation requires certain amount of skill for its successful outcome to minimize risk of failure[1,2].

To enhance the success of intubation, various alternatives to conventional laryngoscopy have been described in recent years, such as the lighted stylet[3], intubating laryngeal mask[4], fibreoptic bronchoscope[5], and video laryngoscope[6]. Although a lot of new tools have been developed to facilitate airway management, direct laryngoscopy remains the most commonly practiced method of performing intubation. As stated by Yang *et al*, these alternatives are costly, technically complicated, and not available everywhere[7]. Therefore, techniques that are inexpensive and easy to handle are still desired. Retrograde light-guided laryngoscopy, an alternative technique was described in a case report by Hudson *et al* wherein successful intubation was achieved after the laryngoscope light failure[8]. The salient feature of this method is that the glottis is visualized using retrograde trans-tracheal light transmission from an external light source attached to the skin, instead of ante grade illumination by DL.

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With this approach, the shining glottis can easily be tracked and identified.

A prospective randomized study comparing retrograde light-guided laryngoscopy with conventional direct laryngoscopy followed by intubation was done by Yang *et al*[7]. RLGL resulted in higher success rate, shorter time for glottis exposure, shorter intubation time and less sore-throat when compared with DL among the novice operators.

This study was undertaken to evaluate RLGL as an alternative technique for tracheal intubation and compare it with conventional DL using Macintosh laryngoscope in the Indian population.

METHODS

This study was conducted in the department of Anaesthesiology of our institute on patients undergoing elective surgery under general anaesthesia. Ethical clearance was taken from the institutional review board.

A prospective randomized study was performed on 100 ASA I/II patients of either sex, between the age group of 18–65 years. A detailed pre-anaesthetic check up and investigations were done as per the age, surgical condition and associated disease of patients. Written informed consent was taken from the patients. The inclusion criteria included a Mallampati score of I–II, thyromental distance ≥6 cm, mouth opening ≥3 cm, body mass index ≤30 kg/m^2, and the absence of temporomandibular joint disease, risks for regurgitation and pulmonary aspiration, and other apparent intubation obstacles. The patients on anti-hypertensive drugs and with cardiovascular disease were excluded from our studies.

100 patients were randomly allocated by computer generated random tables to one of the two groups comprising 50 patients each.

The Group **DL** where direct laryngoscopic intubation was performed and the Group **RLGL** where retrograde light-guided laryngoscopic intubation was performed.

On the OT table, patients were placed in supine position. All patients were monitored with electrocardiography, pulse oximetry, and non-invasive arterial blood pressure. The patients were preoxygenated for at least 3 min. Induction of general anaesthesia was done with fentanyl (2 mcg/kg), propofol (2 mg/kg), and muscle relaxation was achieved with vecuronium (0.1 mg/kg) and lungs were ventilated with oxygen, nitrous oxide and 1% isoflurane. The patient's head was elevated with a 7 cm pillow under the occiput and head was extended into the sniffing position.

The Macintosh laryngoscope was grasped in the left hand, and the blade was inserted with light source ON between the teeth in patients of DL group. The laryngoscopy was performed with the standard direct laryngoscopic technique to expose the vocal cords. The Cormack Lehane grade of glottis exposure was judged and the tube was passed through the vocal cords.

For patients of RLGL group, an assistant held the flashlight (LED) in place over the caudal edge of thyroid cartilage (cricothyroid membrane) for retrograde light-guided laryngoscopic intubation and kept the OT illumination with minimum light. The Macintosh laryngoscopic blade was introduced with light switched off (by removing the batteries) until the illuminated glottis was seen against the dim red background. The Cormack Lehane grade was noted and endotracheal tube was inserted into the trachea following the illuminated glottis as a target, and its cuff was inflated.

Figure 1: Retrograde Light Guided Laryngoscopy.

The time for each intubation was limited to 120 seconds. The time to exposure and intubation was measured with the stop-watch. An assistant started the stop-watch as soon as the laryngoscopy was started, stopped the watch when the operator reported his best view of glottis, and stopped the watch again once the tube was in place and its cuff was inflated.

Failure of an attempt was defined by the following: resistance to passing the tube; withdrawal of the tube from the mouth in an attempt to re-expose the glottis; and signs of an esophageal intubation. In case of failure, a new intubation attempt was immediately performed, and a total of two attempts were allowed for each patient. It was decided to discontinue the protocol and take over the intubation if one of the following situations occurred: the time required for glottic exposure and tracheal intubation exceeded 120 s; the intubation attempt failed twice; the oxygen saturation decreased below 95%; the blood pressure or heart rate fluctuated by more than 25%; or any airway injury, as evidenced by blood staining on the Macintosh blade or the head end of the tracheal tube, occurred.

Time to glottic exposure was observed as soon as the patient's mouth was opened and till the operator reported his best view of the glottis.

Time to tracheal intubation was recorded from glottic exposure to the placement of the tube.

The operator was given at the most two attempts for each patient the time limit was 120 sec for the intubation and the success rate was calculated on the basis of number of attempts.

The CL grading was used for the assessment of glottis exposure. SBP (Systolic Blood Pressure), DBP (Diastolic Blood Pressure) and HR (Heart Rate) were monitored at the time of introduction of laryngoscope, thereafter at every 2 minutes till 10 minutes.

The incidence of sore throat was evaluated 24 h after intubation by staff members who were blind to the patient's grouping using Sore-Throat Score and Hoarseness Score[9].

Complications (if any) were noted and compared in the above two groups.

Statistical analysis was done using SPSS statistical software version 15.0 and p value <0.05 was considered statistically significant.

A previous study[1] taking the success rate of tracheal intubation as the primary test criterion, estimated it to be 50% for DL intubation and 70% in RLGL group with a between-group difference of 20%. Assuming this difference to be significant, we estimated the minimum required sample size in each group with 90% power and 5% level of significance to be 48 patients in each group. A sample size of 100 was chosen for our study having 50 patients in each group.

The demographic characteristics were compared using a two-sample t-test for continuous data and a Pearson chi-square test for categorical data.

For quantitative data, for comparison between the two groups, difference between the two means was observed by unpaired t-test and Mann Whitney test.

For paired observations (comparison of observation at different periods of time), paired t-test, and Wilcoxon test were applied. Chi square/Fisher Exact test was used for computing qualitative variables (and other categorical variables if any).

RESULTS

A total of 100 tracheal intubations were performed. According to the exclusion criteria, one patient was excluded from the analysis as he developed severe bradycardia. No patient experienced complications, adverse events, or observable harm as a result of the protocol. All the patients were similar in regards to age, sex (male/female) body weight, height, body mass index, ASA class I/II, thyromental distance, mouth-open, Mallampati score, I/II as seen in Table 1.

Table 1: Demography of the patients

	Total (100)	DL (50)	RLGL (50)
Age (years)	29.48±9.96	28.54±9.84	30.42±10.09
Gender (M/F)	32/68	18/32	14/36
ASA (I/ II)	94/6	47/3	47/3
MPC(1/2)	59/41	29/21	30/20

Data presented as mean ± SD or actual numbers; DL-Direect Laryngoscopy; RLGL-Retrograde Light-Guided Laryngoscopy; MPC -Mallampati class.

The time to glottis exposure started as soon as the patient's mouth was opened and till the operator reported his best view of the glottis.

In our study, we found that the mean time taken for glottis exposure with RLGL was faster which was 4.0(±1.09) sec as compared to the mean time taken for DL group which was 4.72±(1.16) sec (p = 0.001).

The time to tracheal intubation started from glotic exposure to the placement of the tube. Similarly the mean time taken for endotracheal intubation was found to be less with RLGL with value of 5.28(±1.34) sec as compared to DL which was 6.10(±1.22) sec (p = 0.001).

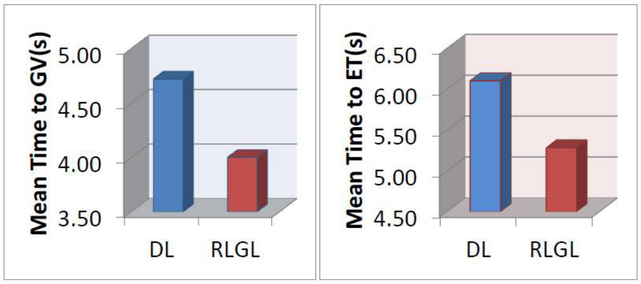

Figure 2: Mean time taken for exposure of glottis view (GV) and mean time taken for endotracheal intubation (ET) in two groups (DL-direct laryngoscopy and RLGL-retrograde light-guided laryngoscopy).

In our study we observed the extent of glottis exposure in both the groups. The extent of glottic exposure was judged by the operator according to Cormacke and Lehane grades[10]. 48 exposures in RLGL group and 40 exposures in DL group were found to be CL grade I. The CL grade II was seen in 1 patient in RLGL group, and 10 patients in DL group 94% (47/49) of the cases in RLGL group were intubated successfully in the first attempt as compared to 78% (39/50) in DL group. Only 4% (2/49) cases required a second attempt for successful intubation with RLGL technique and 22% (11/50) cases with DL technique. One patient was excluded from our study because of severe bradycardia developed in that patient. Compared to the DL group, the overall success rate (P = 0.004) was higher in the RLGL group. The success rate was considered to be 100% if patient could be intubated with single attempt, and the success rate was considered to be 50% if could be intubated with 2nd attempt. Based upon this, the mean success rate for endotracheal intubation was significantly higher in RLGL group (97.96±10) while it was lower in DL group (89.00±20.92). (P = 0.004)

There was no failure of intubation in both the groups.

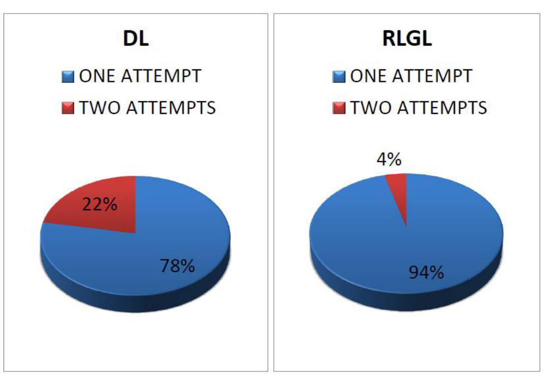

Figure 3: Comparison of percentage of number of attempts for endotracheal intubation in the two groups. (DL-direct laryngoscopy and RLGL-retrograde light guided laryngoscopy).

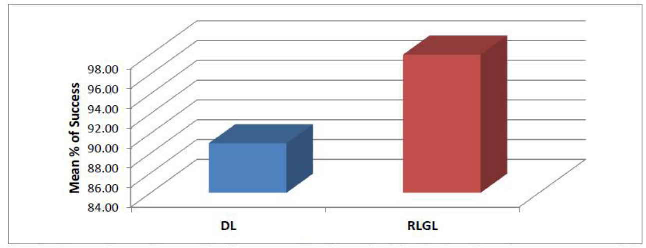

Figure 4: Comparison of mean % of success of endotracheal intubation (based on no. attempts) in both the groups (DL-direct laryngoscopy and RLGL-retrograde light guided laryngoscopy)

The Systolic Blood Pressure (SBP), Diastolic Blood Pressure(DBP) and Heart Rate (HR) showed similar pattern of changes with initial increase at 2 min and then gradual decrease at 4min denoting that both the techniques have same effects on haemodynamic parameters (p>0.05). Though at all times the haemodynamic parameters were more in DL group, these differences were significant only after 6min.

At 24 hr after intubation, a total of 4 patients intubated using RLGL complained of a sore throat, of which 3 patients had sore throat score of 1 and one patient had sore-throat score of 2. 10 patients who were intubated using DL (P = 0.083) developed sore throat of which 9 patients had sore throat score of one and 1 patient had sore-throat score of 2. The hoarseness of voice score was 1 in 8 patients and 2 in 1 patient in DL group as compared to RLGL group where the sore-throat score was 1 in one patient.

From the analysis of above data we found that the incidence of sore throat was less in RLGL group as compared to DL group but difference was not significant (p = 0.083).

Similarly the incidence of hoarseness of voice was found to be significantly less in RLGL group in comparison with DL group (p-value = 0.005).

DISCUSSION

Our data has shown that, compared to DL, intubation was achieved faster and with greater success rate in RLGL with comparable haemodynamic changes and lesser incidence of post op sore-throat and hoarseness of voice. These results could not have been attained from bias with regard to patient allotment because the randomized allocation of patients to the intubation methods generated two homogeneous study groups without differences in the anaesthesia-related variables, such as body size, ASA classification, or potential intubation difficulties.

Our results were similar to those obtained by Yang *et al*., where they chose novice operators to perform their study[7].

In our study the operator was not a novice but was experienced and had performed more than 47 successful intubations to reach the competency of laryngoscopic intubation[2].

The exposure of the glottis is a critical step for tracheal intubation[3,6]. It is easier to track the intensely "red glowing" glottis by using RLGL than by using DL[7]. Moreover, the disappearance of the illuminated glottis around the tube after intubation is evidence for successful intubation by RLGL, which makes the whole intubation process effective and time saving. The results suggest that different light conditions in the target area may explain the advantage of RLGL over DL. The proper alignment of the optical axis between the observer and glottis is critical and is a requirement for both methods. Second, the light intensity must be appropriate to identify the glottis. DL usually provides visibility conditions sufficient for viewing structures in the neighbourhood of the glottis as important landmarks for localizing the glottis if it is initially not visible. By retrograde light transmission, these structures, although only faintly visualized, can also be used for initial orientation. However, these structures are not essential for exposing the glottis with RLGL because the technique relies primarily on illumination of the glottis and the structures cranial to it as a guide. This is analogous to the orientation in a tunnel, where the light at the exit marks the destination[7]. Though the effect of light and illumination during laryngoscopic intubation is not studied much, it can further be explained by the Helmholtz–Kohlrausch effect which is impacted by the viewing environment[11]. This includes the surroundings of the object and the lighting that the object is being viewed under. The Helmholtz–Kohlrausch effect works best in darker environments where there is not any other outside factors influencing the colors. For example, this is why theaters are all dark environments.

Visualization of the larynx at the time of direct laryngoscopy is dependent upon adequate illumination of the airway tissues by the laryngoscope[12,13]. Illumination of the airway is determined, in part, by the intensity and the colour of the light cast and the area (light field) over which the light is cast. The intensity and colour of the light and the nature and dimensions of the laryngoscopic light field are influenced by the nature of the bulb (finish, composition, power rating), the potential of the power source applied to the bulb and, in fibreoptic systems, the characteristics of the fibre-bundle[14].

Further the light reflection from the surface covered with mucus hinder the view of glottis exposure as generally encountered during direct laryngoscopy while this phenomenon is absent in RLGL.

Also in RLGL Group, the light is coming from opposite direction, so that the whole of shining glottis can easily be seen, while in DL group the light is coming from the same side of viewing, so that the light falls over anterior surface of epiglottis causing some shadow of it over anterior commissure of glottis. This may be the reason that the CL grades become higher in DL group. But this aspect of explanation needs further exploration.

The incidence of postoperative sore throat and hoarseness of voice was also lower with RLGL compared to DL. This difference can be attributed to the faster technique of RLGL and also the light sources in DL cause direct burn of tissues in the laryngopharyngeal cavity resulting in sore-throat.

We are aware of the several limitations and shortcomings of our study. First, this study could not be blinded because the operator knew both intubation techniques just prior to the begining of intubation. Second, our observations apply to a select group of subjects who were healthy and had no apparent obstacles to intubation. Therefore, it is still to be seen if RLGL may also be helpful for difficult intubations. Third, the light intensity of the flashlight used in the RLGL group had been pre-tested for our select group of patients before this study to guarantee the best view in the laryngeal cavity. Fourth, RLGL required an additional assistant to hold the flashlight in place. In the future, the manpower needed for RLGL could be reduced by developing a light source that is fixed on the skin. Fifth, C & L grades were better with RLGL, but with the different light sources and light conditions in the laryngeal cavity the two groups were not exactly similar. However, these observations must be interpreted with caution because we took the homogenous group with normal BMI and exclusion of predicted difficult intubation. Utilisation of this technique with predicted difficult intubation is a future scope for intubation. Furthermore this technique can be utilised for teaching novice operators to gain its faster successful application and in cases of laryngoscopic light failure.

CONCLUSION

We conclude that the RLGL is a safe and effective device for achieving endotracheal intubation in normotensive adults with normal airways. It is a simple, inexpensive, and easy-to-learn technique that may supplement conventional laryngoscopy. With this method in our study, intubation is more effective than with conventional DL. Its proper operation and effectiveness need to be further explored.

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