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Comparison of the C-mac, truview and conventional Macintosh direct laryngoscope for intubation in patients undergoing surgical procedure under general anesthesia

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Abstract
Background & Objectives: Managing the airway is one of the commonest challenges an anesthesiologist encounters in routine practice. Inadequate ventilation, difficult and failed endotracheal intubation may lead to hypoxia resulting in increased adverse respiratory events and worse outcomes in both operative and emergency settings. In recent years, video-laryngoscopes have gained much popularity, including Truview-EVO2 laryngoscope, C-MAC video-laryngoscope, and various other varieties of video-laryngoscope. This study is designed to compare the C-MAC, Truview, and Macintosh laryngoscope for intubation in patients undergoing surgical procedure concerning ease of intubation.

Material & Methods: 228 patients with ASA status I-II were randomly selected and divided into 3 groups, Macintosh (M), Truview (T), C-MAC (C), comprising of 76 patients in each group. Our database compared laryngoscopy and intubation time (seconds), Cormack-Lehane (C-L) score, laryngoscopic maneuvers, complications, and hemodynamics among 3 groups.

Results: The mean laryngoscopy time (seconds) was significantly longer with T group (19.09±2.69) as compared to C (16.18±1.55) and M groups (12.0±1.36). However, C-L grade I was higher in group C as compared to other groups ($p<0.001$). Requirement of backward-upward-rightward pressure was significantly higher in M group than other groups ($p=0.001$). Sore throat was present in 3(4.17%), 4(5.56%) and 7(9.72%) patients in C, T and M groups, respectively within 24 hours post-operatively. There was significant rise in heart rate, systolic and diastolic blood pressures at 1-minute post-intubation in group T as compared to other groups from the baseline ($p<0.01$).

Conclusion: C-MAC video-laryngoscope and Truview-EVO2 provide better glottic visualization and C-L grades with lesser requirement of laryngoscopic maneuvers. However, time to intubation with Truview laryngoscope is prolonged, as tube advancement towards the glottic inlet is comparatively difficult, requiring hand-eye coordination, resulting in significantly higher post-intubation hemodynamic parameters. In sum, these video-laryngoscopes by a well-trained anesthesiologist may be an essential tool for difficult intubation.

Keywords: Macintosh laryngoscope, C-MAC laryngoscope, truview laryngoscope, Cormack-Lahane grade

Introduction
Managing the airway is one of the commonest challenges an anesthesiologist encounters in routine practice. Complications due to difficult or failed tracheal intubations are one of the leading causes of anesthesia related morbidity and mortality [1-3]. Inadequate ventilation and failed endotracheal intubation can potentially lead to adverse respiratory events such as/ hypoxia, which results in worse outcomes in both operative and emergency settings [4-6].

Most commonly used device for visualization of the laryngeal structures is Macintosh laryngoscope, a conventional direct laryngoscope, facilitating tracheal intubation. For adequate exposure of glottis, the patient needs to be in sniffing position (extension at the atlanto-occipital joint, flexion at the lower cervical spine) for endotracheal intubation with direct laryngoscopy. It is important to maintain the oral, laryngeal, and tracheal axes to gain direct glottic aperture view to facilitate tracheal intubation with conventional direct laryngoscopy [7]. Glottic view can be improved by external laryngeal manipulation like backward-upward-rightward pressure (BURP). Requirement of external laryngeal manipulation and number of attempts are indicators of difficulty encountered while performing laryngoscopy and intubation. The magnitude of hemodynamic response with a laryngoscopic blade increases with the force on the base of tongue while lifting the epiglottis and by prolonged duration of laryngoscopy and intubation [8].

Cormack-Lehane (C-L) classification is a grading system that is commonly used to demonstrate the laryngeal view during direct laryngoscopy [9]. Ever since the development of Mallampati classification, several aids and techniques have been devised for managing difficult airway situations [10, 11].

In recent years, video-laryngoscopes, working on the principle of indirect laryngoscopy, have gained much popularity [12-15]. These include: Truview EVO2 (Truphatek International Ltd, Netanya, Israel) laryngoscope, C-MAC video-laryngoscope (Karl Storz Tuttlingen, Germany) and various other varieties of video-laryngoscopes. Truview is available as Truview EVO2 and Truview Premier with and without a pre-mounted camera while Karl Storz video-laryngoscopes have four distinct generations. C-MAC is a fourth-generation video-laryngoscope that works on the principle of complementary metal oxide semiconductor technology. Video-laryngoscope has a micro video camera on the undersurface of its blade, which allows visualization of the airway on the video monitor, providing the operator with an indirect view of the larynx and minimizing problems encountered with obtaining a direct sight line to the airway.

Definitive advantages of these new devices have been shown over conventional Macintosh laryngoscope, including better glottic visualization, a requirement of less optimizing maneuvers for a successful intubation and more favorable hemodynamic parameters during intubation [16-19]. Video-laryngoscopes have now been included in the American Society of Anesthesiologists (ASA) difficult airway algorithm (2013) as an initial modality in anticipated difficult airway and as an alternative approach in the non-emergency pathway following attempt of unsuccessful intubation with Macintosh laryngoscope [20].

There have been individual comparisons of Truview and Macintosh or C-MAC and Macintosh laryngoscopes in several studies. However, there are very few literatures so far showing comparison of Truview, C-MAC and Macintosh laryngoscopes in adult patients. We compared all three generations of laryngoscopes in adult patients, aiming to study intubation in a wider perspective, considering the glottic exposure (C-L grade), total intubation time, laryngoscopic maneuvers to aid intubation, associated complications and hemodynamics in patients requiring endotracheal intubation with general anesthesia in various surgical procedures.

Material and Methods

After receiving approval from the institutional ethical committee, a prospective randomized comparative study was conducted in patients undergoing surgical procedures requiring general anesthesia over a duration of 2 years in a multispecialty institute. The study included 228 American Society of Anesthesiology (ASA) physical status I or II patients, aged 18 to 60 years. The study design is depicted in Fig. 1.

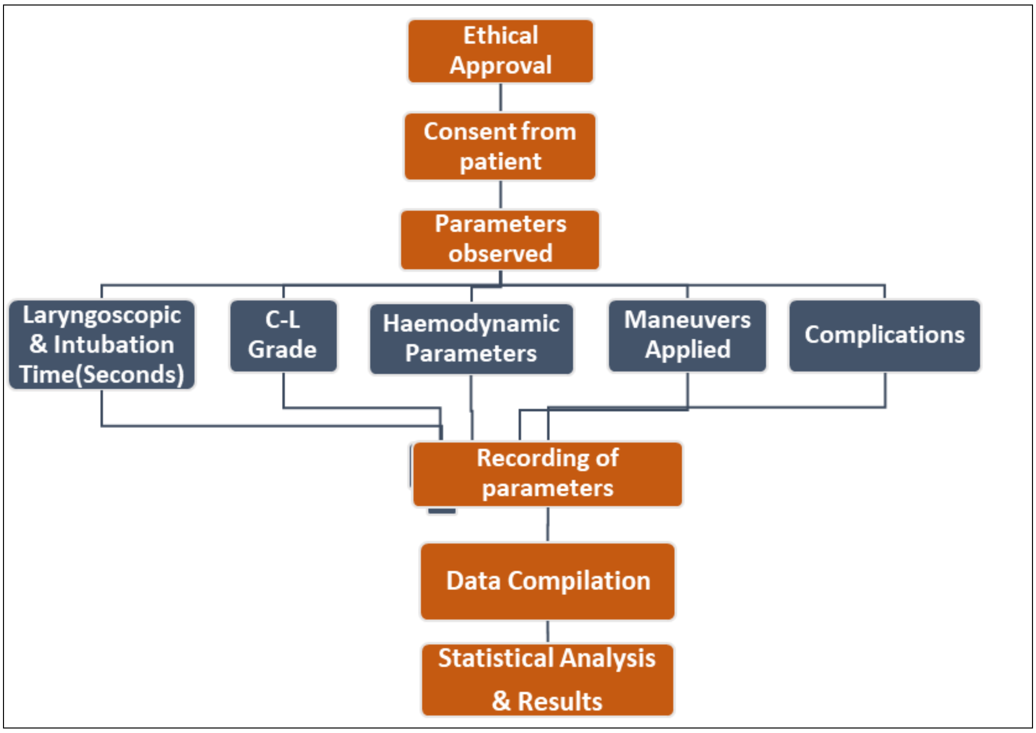

Fig 1: Study design of randomized comparative trial

Patients with Malampatti score (I, II), Adequate neck movement, mouth opening ≥ 3 c.m, Mentothyroid distance ≥ 6.5 c.m. were included in the study. While, patient with anticipated difficult airways (including previous history of difficult intubation, cervical spine pathology and restricted neck movement, high risk of aspiration (including patient of < 6 hours of nil by mouth, pregnancy, Gastro esophageal reflux disease), Obesity (BMI > 35 kg/m2), recent respiratory tract infection (within 10 days prior surgery), surgery involving pharynx and larynx and prolonged surgery (surgery >3 hours) were excluded from the study. Patients were divided into 3 groups: Macintosh (M), Truview (T), C-MAC (C), comprising of 76 patients in each group.

After taking study consent, the allocation sequence was generated by a random number table preoperatively, which was concealed in sealed envelopes. All patients received Tab. Alprazolam 0.25 mg and Tab. Pantoprazole 40 mg on the morning of surgery. On arrival of the patient in operating room, a sealed envelope was opened by a senior colleague who was not involved in the study. Routine ASA standard monitoring was noted. Intravenous injection of Glycopyrrolate (0.2 mg) and injection of Midazolam (1mg) were administered 10 minutes before induction of anesthesia. All patients were pre-oxygenated for 3 minutes. Fentanyl 1-2 mcg/kg, Propofol 1-2 mg/kg, Atracurium 0.5mg/kg were given intravenously after adequate pre-oxygenation. After adequate muscle relaxation (Train of four responses=0), laryngoscopy was performed with the assigned laryngoscope (as per opaque sealed envelopes), either Macintosh, Truview EVO2 or C-MAC laryngoscopes. Later patient was maintained on Sevoflurane as an inhalational agent with oxygen.

Intubations were performed by a single senior experienced anesthetist who had carried out more than 50 successful intubations with Macintosh, Truview and C-MAC video-laryngoscopes.

Intubation attempt was considered once the laryngoscope blade crossed the lip.

The following parameters were recorded during study:

1. Laryngoscopy time (seconds) was recorded as time from picking up of laryngoscope until visualization of glottis
2. Intubation time (seconds) was taken as time from picking up of laryngoscope until first breath given through bag or closed circuit confirmed by capnography
3. Cormack-Lehane score (grade I, II, III, IV)
4. Number of attempts (1, 2, 3)
5. Laryngoscopic maneuvers

I) BURP

II) Use of Bougie

1. Successful intubation confirmed by capnography (yes/no)
2. Dental injury (yes/no) and sore throat (yes/no) postoperatively within 24 hours after operative procedure.
3. Hemodynamics (H.R., B.P., Spo2) were recorded as follows:

I) 1 minute after intubation

II) 5 minutes after intubation

Statistical analyses were performed using statistical software STATA version 12 (STATA Corp., TEXAS, USA). Descriptive statistics were presented. The quantitative variables were presented as Mean and standard deviation, and categorical variables were presented as numbers and percentages. Median and inter-quartile range were presented, when data is not normally distributed and Kruskal-Walli's test was performed to find out the difference between the groups. Chi-square test was applied for categorical variables. A one-way ANOVA test was used to find a significant difference between the groups.

Results

Table 1: Demographic profile of patients undergoing tracheal intubation with different laryngoscopes. Values are mean ±SD or number (%)

Characteristics	Group C (N= 76)	Group T (N= 76)	Group M (N= 76)	P value
Mean Age (Years)	37.53±10.32	39.89±11.62	40.07±11.13	0.28
Gender				
Male	28 (36.84%)	24 (31.58%)	28 (36.84%)	0.73
Female	48 (63.16%)	52 (68.42%)	48 (63.16%)	
Mean Weight (kg)	68.29±8.66	65.74±7.46	65.92±10.31	0.14
Mean Height (cm)	163.80±8.66	161.74±5.87	164.01±7.42	0.11
Mean BMI (kg/m2)	25.61±2.50	25.14±2.70	25.49±3.34	0.06
ASA Grade				
I	64 (84.21%)	58 (76.32%)	62 (81.58%)	0.45
II	12 (15.79%)	18 (23.68%)	14 (18.42%)	

Table 2: Study Variables

Parameters	Group C (N= 76)	Group T (N= 76)	Group M (N= 76)	P value
Mean Laryngoscopic time (Sec)	16.18±1.55	19.09±2.69	12.0±1.36	<0.0001
Mean intubation time (Sec)	48.34±3.45	51.0±5.32	21.89±2.14	<0.0001
C-L Grade				
I	69 (90.79%)	66 (86.84%)	37 (48.68%)	
II	7 (9.21%)	10 (13.16%)	31 (40.79%)	<0.001
III	0	0	8 (10.53%)	
Maneuvers				
BURP	7 (9.21)	9 (11.84)	21 (27.63)	0.003
Bougie	0	0	0	NA
Complications				
Dental injury(yes/no)	0	0	0	NA
Sore throat (yes/no)	3 (3.95%)	4 (5.26%)	7 (9.21%)	0.37

Table 3: Comparison of changes in Heart Rate per minute among the three groups

Duration (Min)		Baseline	Post intubation	
			1 min	5 min
Group C (N= 76)	Mean	81.95	94.11	81.82
	SD	3.50	3.89	4.18
	95% CI	81.14 – 82.75	93.21– 94.99	80.86 – 82.77
Group T (N= 76)	Mean	82.43	95.85	82.75
	SD	4.05	4.61	3.90
	95% CI	81.51 – 83.36	94.80 – 96.91	81.85 – 83.64
Group M (N= 76)	Mean	82.70	92.5	82.97
	SD	5.91	5.52	5.78
	95% CI	81.35 – 84.05	91.24 – 93.76	81.65 – 84.29
F Statistic		0.52	9.60	1.30
P value		0.60	<0.001	0.27

Table 4: Comparison of change in Systolic Blood Pressure among the three groups

Duration (Min)		Baseline	Post intubation	
			1 min	5 min
Group C (N= 76)	Mean	124.14	135.97	123.38
	SD	2.88	4.39	5.01
	95% CI	123.48 – 124.80	134.97 – 136.97	122.23 – 124.52
Group T (N= 76)	Mean	124.59	138.18	124.67
	SD	4.62	4.43	4.45
	95% CI	123.53 – 125.64	137.17 – 139.19	123.65 -125.68
Group M (N=76)	Mean	124.98	133.77	124.62
	SD	5.68	5.17	5.90
	95% CI	123.68 – 126.28	132.59 – 134.96	123.26 - 125.96
F Statistic		0.65	16.88	1.52
P value		0.52	<0.001	0.22

Table 5: Comparison of change in Diastolic Blood Pressure among the three groups

Duration (Min)		Baseline	Post intubation	
			1 min	5 min
Group C N=76	Mean	80.12	90.41	79.71
	SD	3.34	4.26	3.93
	95%CI	79.35-80.88	89.43-91.38	78.81 – 80.61
Group T N=76	Mean	80.18	91.99	80.12
	SD	3.68	4.09	3.64
	95%CI	79.34-81.03	91.05-92.92	79.29 – 80.95
Group M N=76	Mean	79.59	88.80	79.45
	SD	4.86	4.67	5.01
	95%CI	78.48-80.70	87.73-89.87	78.30 – 80.59
F statistics		0.50	10.19	0.49
P value		0.61	<0.001	0.61

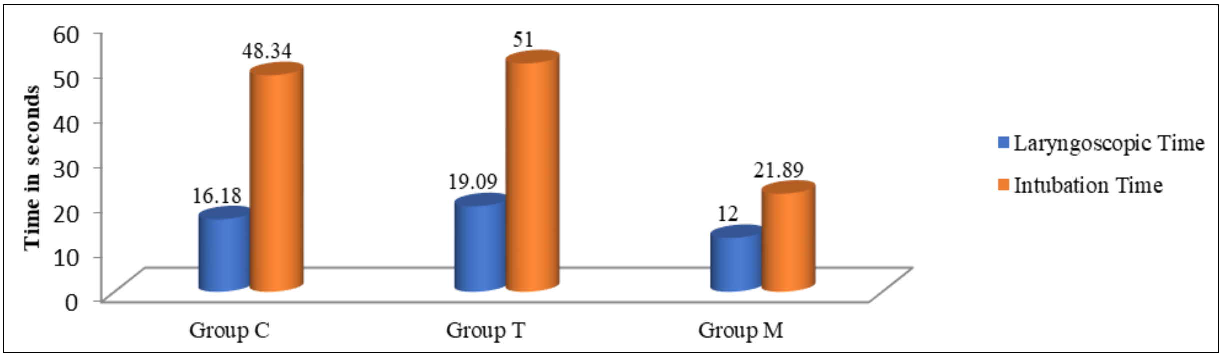

Fig 2: Mean laryngoscopic and intubation time in each group

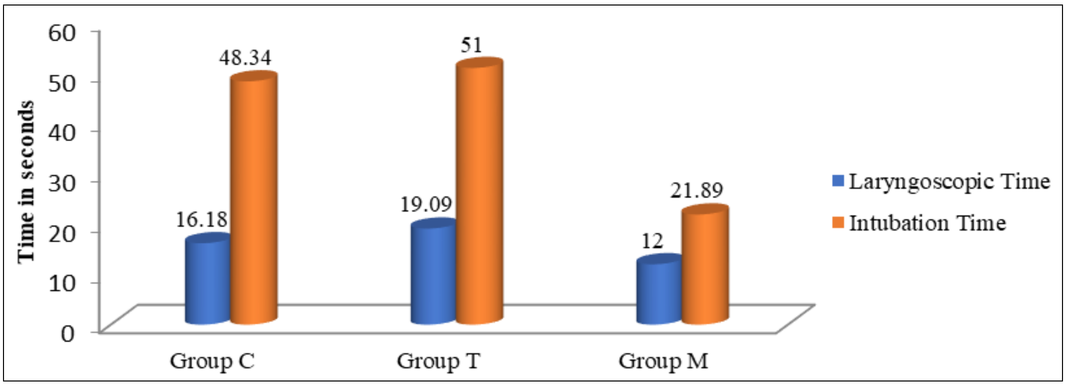

Fig 3: Comparison of C-L grade amongst the three groups.

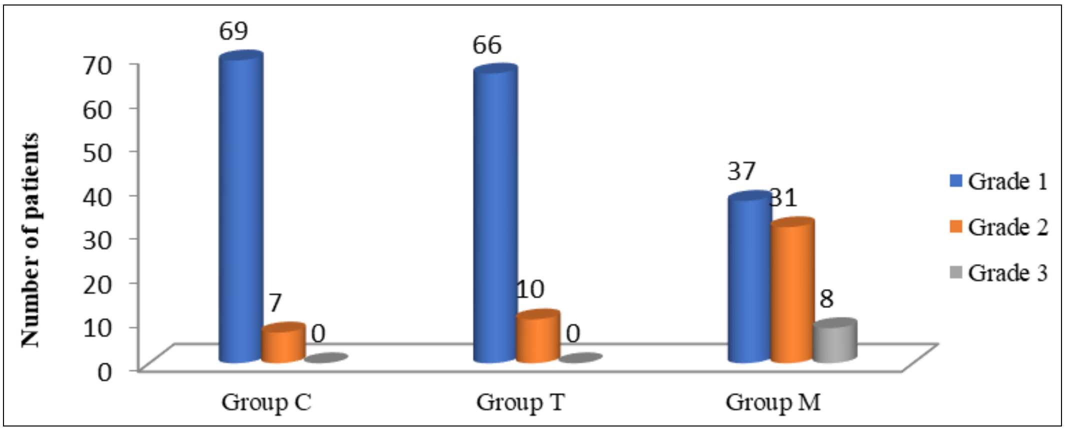

Fig 4: Comparison of changes in mean heart rate among the three groups.

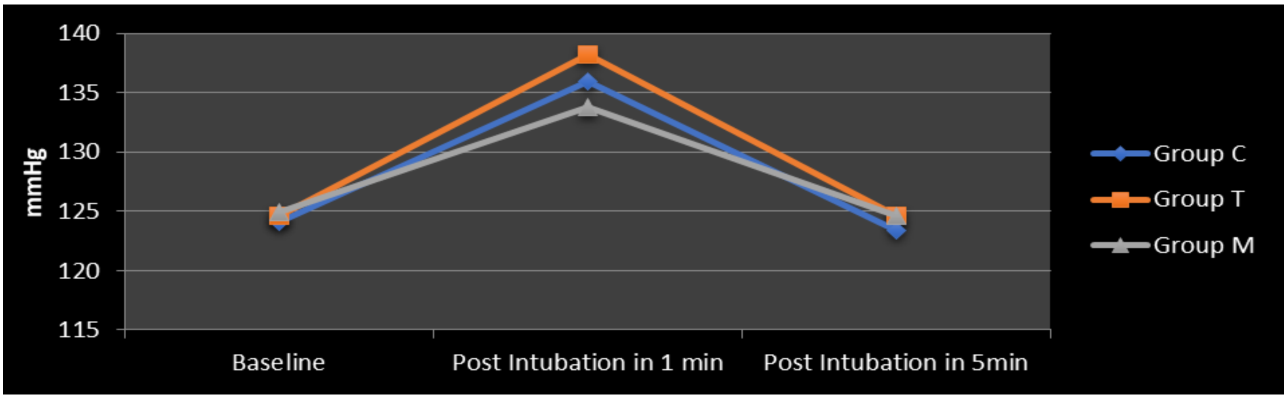

Fig 5: Comparison of changes in mean systolic blood pressure (SBP) among the three groups

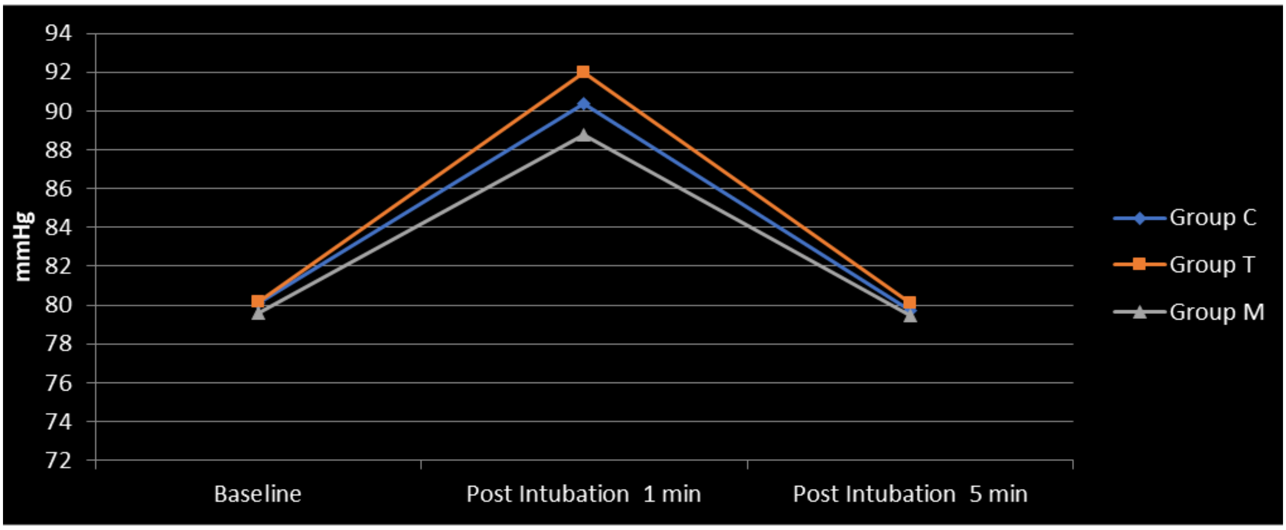

Fig 6: Comparison of changes in mean diastolic blood pressure (DBP) among the three groups

Table 2 denotes parameters during the study, viz, mean laryngoscopy time (sec), mean intubation time (sec), C-L grade, maneuvers and complications.
Data from 226 patients were analysed. Table 1. Depicts demographic data that were comparable amongst all three groups.
The mean laryngoscopic (seconds) time (C- 16.18±1.55; T- 19.09±2.69; M; 12.0±1.36 sec) was significantly higher in group T as compared to other groups ($p<0.0001$). The mean intubation duration (C-48.34±3.45; T- 51.0±5.32; M- 21.89±2.14) was also significantly raised in group T as compared to rest of the groups. (p-0.0001). (Fig 2).
In Group C, a higher number of patients had C-L grade I (n-66) (p < 0.001). While in Group M, more patients had C-L grade II (n-31) and III (n-8) as compared to other groups. None of the patients had C-L grade III in group C and group T. Group C (grade I-69 & grade II-7) and T (grade I-66 & grade II-10) were comparable with regard to C-L grade. (grade I; $p=0.54$ and grade II; $p=0.59$) (Fig 3).
A significantly higher number of patients in group M required BURP as compared to group T and group C ($p=0.003$). Group C and group T were comparable regarding requirement of BURP ($p=0.60$). The incidence of sore throat in all patients within 24 hours post-operatively was comparable ($p=0.37$). None of the patients in any of the groups had dental injury.
Table 3 shows changes in heart rate (per minute) from baseline post-intubation. Mean heart rate at 1 minute was significantly higher in group T (C- 94.11; T- 95.85; M- 92.5) as compared to other groups ($p<0.001$) (Fig 4). Table 4 denotes changes in systolic blood pressure (SBP) (mm Hg) after intubation. Mean SBP (C- 135.97; T- 138.18; M- 133.77) was significantly higher in group T as compared to other groups ($p<0.001$) (Fig. 5). Table 5 shows changes in diastolic blood pressure (DBP) (mm Hg) after intubation. Mean DBP (C- 90.41; T- 91.99; M- 88.80) was significantly higher in group T as compared to other groups ($p=0.001$) (Fig 6).
However, Heart rate, SBP and DBP after 5 minutes achieved nadir from baseline (HR-p:0.27; SBP-p:0.22; DBP-p:0.61).

Discussion

Various types of laryngoscopes with different technical specifications and operational characteristics have been developed. However, Macintosh laryngoscope remains the most widely used in routine practice. The newer Truview laryngoscope has an optical accessory, a different blade angle and an oxygen flow apparatus attached to the device. Similarly, C-MAC video-laryngoscope has the advantage of providing both direct laryngoscopic view and a camera view that is displayed on the screen [21]. To overcome the issues related to the difficult intubation with conventional direct laryngoscopy, these new devices need to be evaluated to propose their relative efficacies over the conventional laryngoscopes.

In our study, the mean laryngoscopy time and intubation time were significantly longer with Truview laryngoscope as compared to C-MAC and Macintosh laryngoscopes ($p<0.0001$). Also, between C-MAC and Truview laryngoscopes, Truview took longer time for laryngoscopy and intubation, which was statistically significant ($p<0.001$). Although Truview and C-MAC laryngoscopes provide a good view of the larynx, they may not guarantee an easy tracheal intubation [22, 23]. Time to successful intubation was rather prolonged owing to indirect view of larynx obtained. This necessitated a skilled hand-eye coordination along with use of stylet and laryngoscopic maneuvers. Delay in intubation was also due to a lesser familiarity of the laryngoscopist with the equipment. Various other studies found similar results wherein time taken for intubation was longer with Truview laryngoscope as compared to Macintosh laryngoscope [24-27]. In a study conducted by Tempe DK. *et al*. duration of laryngoscopy and intubation was significantly less in Macintosh as compared to MacGrath and Truview laryngoscopes. According to them, video-laryngoscopes occupy larger space, not allowing tongue to be pushed to the left side, thereby reducing the available space to insert the endotracheal tube. Fogging of the MacGrath lens due to expired gases also prolonged the intubation time, as clear visualization of the glottis was not possible [28].

As compared to Macintosh laryngoscope, the duration of laryngoscopy and intubation was significantly longer with C-MAC laryngoscope in our study. In a study conducted by Hodgetts V. *et al*. on 90 patients, though the median laryngoscopic time and total intubation time for the C-MAC were significantly higher than Macintosh laryngoscope, but difference was clinically not significant [29]. Jungbauer A.*et al*. prospectively evaluated the conditions and found that video-laryngoscopy produced better visualization of glottis, higher success rate and shorter intubation time, contrary to other studies [30]. Mutlak H. *et al*. conducted a study on 65 children with a bodyweight ≤10 kg (0-22 months) found that intubation time was significantly longer using the TruView EVO2 [31]. The lesser difference in the intubation time of C-MAC and Macintosh laryngoscopes was probably becuase participating anesthesiologists were equally conversant with use of C-MAC laryngoscope having Macintosh blade.

We observed that number of patients with C-L grade I was significantly higher in group C as compared to group T and group M ($p<0.001$). Although this difference was statistically insignificant in group C as compared to group T ($p=0.46$). Patients intubated with Macintosh laryngoscope had a significantly higher C-L grades (II and III) as compared to Truview and C-MAC video-laryngoscopes ($p<0.001$). Therefore, glottic visualization was better with C-MAC and Truview laryngoscopes as compared to Macintosh laryngoscope using C-L criteria. In concordance with our study, Kaplan MB.*et al*. indicated that video-assisted laryngoscopy provides an improved view of the larynx, as compared to direct visualization [15]. The possible reasons for an improved view with the video monitor was positioning of the image fiber bundle tip close to the blade tip, which changes the viewpoint from a straight line of sight, as required for conventional laryngoscopy. Also, closer viewpoint to the glottis provides a wider view, which is transmitted to the video monitor. A study by Li JB.*et al*. concluded that Truview laryngoscope provided significantly better view of the glottis as compared to traditional Macintosh laryngoscope [25]. Similarly, Tutuncu AC. *et al*. in 185 patients, also found that the C-L scores were significantly better for Truview EVO2 than for the Macintosh Laryngoscope blade. Despite better glottic view, intubation failure rate was 2.16% (n=4) in this study. The optical system in the Truview EVO2 laryngoscope enabled a greater view angle in the larynx without alignment of oral, pharyngeal, and tracheal axes [32]. However, Hodgetts V. *et* *al*. found no significant differences in the laryngoscopic view between C-MAC and Macintosh laryngoscopes. This may be due to, similar design of blades and the two patient groups were of similar demographics, as explained by author [29].

Requirement of BURP with Macintosh laryngoscope was significantly higher than with C-MAC and Truview laryngoscopes (p=0.001). BURP maneuver was required less frequently with C-MAC laryngoscope as compared to Truview laryngoscope, but the difference was statistically insignificant (p=0.6). None of the patients required Bougie in any of the groups. A similar result was observed where need for optimizing maneuvers was significantly less in video-laryngoscope as compared conventional laryngoscope [30, 33-37].

Sore throat was statistically insignificant in all three groups. None of the patients in any of the groups had dental injury, similar to various studies between video and conventional laryngoscopes [26, 29, 31, 37, 38]. Bhat R.*et al*. observed greater mucosal injury with Macintosh laryngoscope as compared to C-MAC video-laryngoscope in patients where intubation was done in lateral position [35]. Similarly, Shah SB. *et al*. reported a higher incidence of complications (trauma, DLT cuff rupture, esophageal intubation) with Macintosh laryngoscope as compared to C-MAC D blade laryngoscope [39]. Direct laryngoscopy for single lumen tube placement using Macintosh laryngoscope requires four times greater lifting force on the base of tongue to expose the glottis compared to a video laryngoscope, translating into greater degree of localized trauma [40]. The Truview blade and C-MAC are designed to enable indirect laryngoscopic view; thus, the anesthetist applies less force on the anterior larynx, resulting in fewer patients with bleeding and soft tissue damage. This may be the reason for fewer complications with such video laryngoscopes as compared to Macintosh laryngoscope. All the patients in our study were successfully intubated on the first attempt of laryngoscopy and intubation.

We observed a significant rise in heart rate, SBP and DBP post-intubation at 1 minute with Truview laryngoscope as compared to C-MAC and Macintosh laryngoscope from baseline (p<0.001). No episode of desaturation or adverse hemodynamic event was observed in any patient. The increased hemodynamic responses during airway management at 1 minute were generally due to the stimulation of the oropharyngeal structures during laryngoscopy or laryngeal stimulation while passing the endotracheal tube through the glottic opening. A study by Gill *et al*. showed that laryngoscopy duration less than 30 seconds did not have any effect on the hemodynamic response [41]. Similar rise in hemodynamic parameters was observed by various authors [28, 42]. However, contrary to our results, Bharti N. *et al* observed a blunted hemodynamic response with the TruView laryngoscope as compared to Macintosh laryngoscope in patients requiring manual in-line stabilization (MILS). MILS of cervical spine prevents head extension and neck flexion resulted in a higher incidence of Grade 3 and 4 laryngoscopic views with conventional laryngoscopy leading to increased hemodynamic parameters with the Macintosh laryngoscope [38]. In a study by Timanaykar RT et. al on Truview and Macintosh blade laryngoscopy, the peak rise in heart rate and SBP above pre-intubation value was not statistically significant in both groups. This was due to short laryngoscopy and intubation times in both the groups. Maximum rise in heart rate above pre-induction value with Truview blade was 13.9/min, while with Macintosh blade was 13.5/min [26]. The laryngoscopic time, intubation time and haemodynamic variations can be minimized by improvising the technique of video-laryngoscopy, which can be achieved with continuous use of these devices frequently.

Limitations of our study include an unintended bias due to an unavoidable unblinded study design. Secondly, we excluded patients with anticipated difficult intubation from our study to have similar intubating conditions in all our patients. Thirdly, alternative methods of airway assessment other than C-L grade, such as POGO (percentage of glottic opening) and the intubation difficulty score, were not considered [43, 44].

Conclusion

C-MAC video-laryngoscope and Truview EVO2 provide better glottic visualization and C-L grades for intubations and hence minimize the requirement of laryngoscopic maneuvers. However, advancement of tube towards the glottic inlet is comparatively difficult with Truview laryngoscope, resulting in significant hemodynamic variation, which can be minimized with gaining hand-eye coordination and with sufficient expertise. Employing these laryngoscopes in routine clinical practice can significantly reduce the incidences of difficult intubation, laryngoscopic trauma, post-laryngoscopic complications and improve overall post-operative outcome

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Author's Contribution

Not available

Conflict of Interest

Not available

Financial Support

Not available

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