Original Article

Comparative evaluation of C-MAC and McGrath MAC videolaryngoscopes with Macintosh direct laryngoscope for endotracheal intubation in adult patients undergoing elective surgeries

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Abstract

Background and Aims: Videolaryngoscopes have an undisputed role in difficult airway management, but their role in routine intubation scenarios remains underappreciated. McGrath MAC is a lightweight laryngoscope with a disposable blade. It remains to be proven if it performs as efficiently as the reusable videolaryngoscopes like C-MAC and whether it has an advantage over standard Macintosh laryngoscope in predicted normal airways.

Material and Methods: We recruited 180 adult patients and randomly divided them into three groups for intubation with either Macintosh laryngoscope (Group-A), C-MAC (Group-B), and McGrath (Group-C). The primary objective was to compare the first attempt success rate. Secondary objectives included Cormack-Lehane (CL) grades, laryngoscopy time, intubation time, ease of intubation, need for optimization manoeuver, and the number of passes to place the endotracheal tube.

Results: The two videolaryngoscopes provided a superior first attempt success rate as compared to Macintosh laryngoscope ($P = 0.027$). The CL grade-I was 100% in group B, 41.7% in group-A and 90% in group-C (B vs C; $P = 0.037$). Laryngoscopy time was 9.9 ± 2.5 s, 12.6 ± 0.8 s, and 13.1 ± 0.8 s for groups A, B, and C, respectively (B vs C; $P = 0.001$). Intubation time was 24.4 ± 12 s, 28.3 ± 1.9 s, and 37.3 ± 5.8 s for groups A, B, and C, respectively ($P < 0.0001$). The number of tube passes was highest in group C.

Conclusion: Videolaryngoscopes provided a superior glottic view and resulted in a superior first attempt success rate as compared to Macintosh laryngoscope. When comparing the two videolaryngoscopes, C-MAC resulted in better intubation characteristics (shorter intubation time, better glottic views, and higher first-attempt success rates) and should be preferred over McGrath for intubation in adult patients with normal airways.

Keywords: Adult, glottis, intratracheal, intubation, laryngoscopes, laryngoscopy

Introduction

Endotracheal intubation is an essential skill for all anesthesiologists to master. Inability to secure the airway timely in patients remains a nightmare for anesthesiologists and is an important cause of anesthesia related mortality.[1] Also, repeated attempts at intubation may adversely affect patient outcomes and are consistent with increased airway and hemodynamic complications.[2] Direct laryngoscopy is the most common technique for endotracheal intubation and has

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been the gold standard for several decades.[3,4] It involves direct visualization of the glottis with the help of a laryngoscope and requires alignment of oral, pharyngeal, and laryngeal axes.

Videolaryngoscopes (VLs) have a video camera that is used in place of line-of-sight visualization to achieve glottic view and endotracheal intubation.[5] VLs are increasingly becoming popular in contemporary anesthesia practice and are now being considered as an initial device for difficult airway scenarios by various airway societies.[6,7] However, the situation is less clear for routine airway management. Furthermore, there is a plethora of such devices in the market and testing their relative efficacy is important to evaluate these new devices to improve airway management outcomes.

C-MAC is a high-resolution, reusable, limited portability VL, which had been successfully used for the management of anticipated and unanticipated difficult intubation in past.[8-10] McGrath is a relatively newer portable Macintosh type of VL with an integrated, 1.7 inch LCD monitor. It has the advantages of portability, lesser cost (approximately 10 times), and single-use plastic blade, which has been turning out to be a favored feature for intubation of patients with a highly infectious disease like the presently ongoing COVID-19 pandemic. Hence, it is important to know whether these single-use blade VLs perform as effectively as the reusable ones like C-MAC. Studies on various VLs have been conducted in patients requiring intubation in an emergency, ICU, in difficult and failed intubation and they have been found to provide superior intubation characteristics over direct laryngoscopes.[8-10] However, there is a paucity of literature on the evaluation of the performance of videolaryngoscopes like McGrath MAC VL for orotracheal intubation in patients with a predicted normal airway and its comparison to C-MAC VL and Macintosh DL. The increasing number of attempts is directly related to airway morbidity and if the use of VL can provide an increased first attempt success rate, it would be highly desirable even in a predicted normal airway as much as it is in a difficult airway. Hence, this prospective interventional randomized trial was conducted to evaluate the effectiveness of two Macintosh types VLs (C-MAC and McGrath MAC) with Macintosh direct laryngoscope with regards to improvement in the first attempt success rate as the primary outcome. The secondary outcomes included laryngoscopy and intubation times, overall success rates, glottic views, ease of intubation, number of passes to place ETT, and any adverse events during intubation with all three devices.

Material and Methods

The present prospective randomized interventional open-label trial was conducted in our institution after institutional ethics committee approval and prospective Clinical Trial Registry India (CTRI/2018/03/012835) registration over 10 months (April 2018–January 2019). After obtaining written and informed consent, 180 adult patients (18–65 years) of either gender scheduled for elective surgery under general anesthesia requiring endotracheal intubation, belonging to American Society of Anesthesiology (ASA) grade I or II, having body mass index (BMI) ≤30 Kg/m^2 with standard airway parameters within normal limits were recruited. Patients having a history of a difficult airway or any indicators (viz., Modified Mallampati class III/IV, thyromental distance <6.5 cm, inter incisor gap <3 cm, sternomental distance <12.5 cm, and restricted neck movements), patients with hemodynamic instability, hypertension, uncontrolled cardiopulmonary dysfunction, upper respiratory tract infection, and cervical spine instability, and pregnant patients were excluded from the study. All recruited patients were randomly divided into three groups by block randomization in blocks of 15 each as follows:

Group A: Direct Macintosh laryngoscope

Group B: CMAC video-laryngoscope (Karl Storz GmbH and Co. KG, Tuttlingen, Germany)

Group C: McGrath video-laryngoscope (Medtronic Inc, Minneapolis, Minnesota, USA)

The patients were kept fasting after 10 pm and were given tablet alprazolam 0.25 mg, ranitidine 150 mg, and metoclopramide 10 mg at 10 pm, a night before the surgery.

On arrival in the operation room (OR), routine monitoring with an electrocardiogram (ECG), pulse oximeter (SPO_2), and non-invasive BP (NIBP) was instituted, and baseline parameters were recorded. An intravenous (IV) line with an 18G cannula was secured. The patient was preoxygenated for 3–5 min with a tight-fitting face mask at an oxygen flow of 10–12 L/min. General anesthesia was induced with inj. fentanyl (2 μg/kg IV) and inj. propofol (2-3 mg/kg IV) and after checking ventilation, injection vecuronium bromide (0.1 mg/kg IV) was given. The patient's lungs were ventilated with oxygen, nitrous oxide (50:50) and isoflurane 0.8%–1% (titrated to a MAC value of 1) for 4 min. After confirming adequate muscle relaxation using neuromuscular monitoring [when Train-of-Four (TOF) count became 0], the laryngoscopy was done with one of the three devices as per group allocation. Two experienced investigators (who had completed >200 intubations with a direct laryngoscope) performed all the intubations in the study. They conducted a pilot case of 20 intubations with each of the study devices to become familiar with equipment use and to grade ease of insertion of

laryngoscope blade as easy and difficult. The blade size of all the three intubation devices (blade size "3" for females and "4" for males), as well as the styletted endotracheal tube (ETT) size (7.0 for females and 8.0 for males) was kept constant. During pilot cases, fogging of the view was noticed while using McGrath VL. Dipping of laryngoscope blade in warm water 10 s before intubation was used to reduce fogging associated with the same. The laryngoscopic view was graded according to the modified Cormack and Lehane (CL) grading scale.[11]

Following endotracheal intubation, the placement of ETT within the trachea was confirmed by visual confirmation of the ET tube between the vocal cords, bilateral chest expansion, 5-point chest auscultation, and a continuous sine waveform capnograph for at least 6 breaths.

Ease of laryngoscopy (easy/difficult), laryngoscopy time (defined as the time from picking up the laryngoscope to the visualization of the glottis), intubation time (defined as the time from picking up the laryngoscope to confirmation of tracheal intubation by 6 continuous capnographic waves), modified CL grade, successful intubation in the first attempt, number of passes to place the tube (number of attempts to pass the ETT into the glottis without removing the intubating device), and need for optimal external laryngeal manipulation (OELM) were recorded. Ease of insertion of the laryngoscope blade and obtaining the glottic view was graded as ease of laryngoscopy by the operator. All parameters were recorded by an independent assessor not involved in the study any further. Times to laryngoscopy and intubation were recorded using a stopwatch. Use of bougie, airway complications following intubation (mucosal/gum bleed or upper airway trauma), episodes of desaturation (SpO_2 <95%), failed intubation, and any esophageal intubations were also recorded. In the case of desaturation, the intubation attempt was aborted, and bag-mask ventilation was initiated before attempting intubation again. Any single insertion of the laryngoscope past the patient's lip was considered an intubation attempt.

If more than one intubation attempt was required, cumulative time of all attempts until confirmation of successful intubation was considered as the total intubation time. Tracheal intubation was considered as a failure if not achieved within two attempts or a maximum of two minutes and subsequent airway management was done as per standard protocol.

The data were entered in MS EXCEL spreadsheet and analyzed by using Statistical Package for Social Sciences (SPSS) software 22.0 (Armonk, NY: IBM Inc.). Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and median. The normality of data was tested by the Kolmogorov-Smirnov test. Quantitative variables were compared by using ANOVA/Kruskal Wallis Test (when the data sets were not normally distributed) between the three groups and Unpaired t-test/Mann-Whitney Test (when the data sets were not normally distributed) between the two groups. Qualitative variables were compared by using the Chi-Square test/Fisher's exact test. A P value of < 0.05 was considered to be statistically significant.

Sample size calculation: There is no previous study having a similar design comparing the three laryngoscopes used in our study. Thus, the sample size calculation was based on the retrospective data on intubation success with CMAC and Macintosh laryngoscopes by experienced anesthesiologists in similar settings in our department before starting the study. We had calculated the sample size using PASS 2008 software (NCSS, Kaysville, Utah, USA). The Macintosh direct laryngoscope had a nearly 80% first-attempt success rate and the C-MAC video method had a nearly 98% first-attempt success rate. Considering the success rate with McGrath MAC as similar to CMAC, a sample of 53 subjects would be needed in each group for a power of 80% and type-I error 2% due to multiple comparisons. Accounting for 15% attrition, we recruited 60 patients in each group.

Results

Two hundred patients were checked for eligibility and a total of 180 completed the study, and their data were analyzed for outcomes as depicted in the consort diagram [Figure 1]. No significant difference was found between the three groups with respect to demographic variables and they were comparable with regards to age, sex distribution, height, weight, BMI, and ASA grade ($P > 0.05$) [Table 1].

Patients with successful first attempt intubation were significantly lower in group A as compared to group B. It was comparable between group B and C ($P = 1$). Though it was statistically comparable between group A and group C, the difference was clinically significant [Figure 2 and Table 1].

A significant difference was seen in the distribution of modified Cormac-Lehane grade in the three groups with significantly higher CL grade in group A as compared to groups B and C [Figure 3 and Table 1].

The mean laryngoscopy and intubation time was significantly higher in group time C as compared to groups B and A respectively [Figure 4 and Table 1].

The majority of patients (173 out of 180) had easy laryngoscopy with comfortable insertion of laryngoscope blade

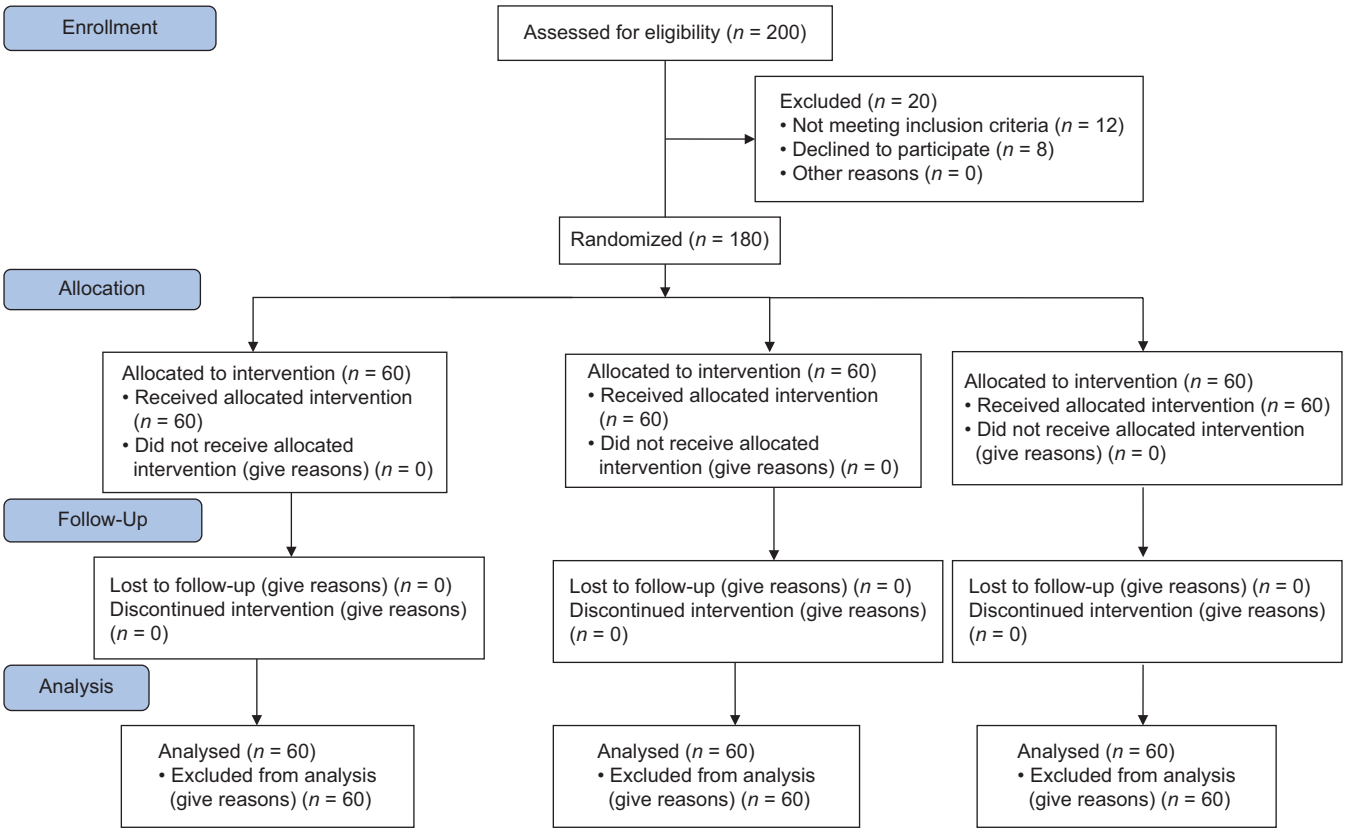

Figure 1: Consort flow diagram

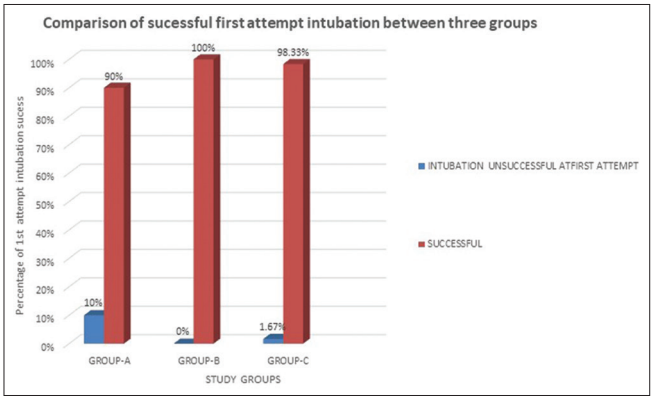

Figure 2: Graphical representation of study groups concerning the percentage of patients with successful first attempt intubation

and obtaining glottic view. All 60 patients (100%) had easy laryngoscopy in group-B (C-MAC), while 5 patients (8%) had difficult laryngoscopy in group-A (Macintosh) [Table 1].

The number of attempts to pass the endotracheal tube without removing the intubating device was maximum with group C, requiring up to 4 passes in 5 patients, suggesting difficulty in maneuvering the tube beyond the glottis [Table 1].

A significantly higher number of patients required OELM with DL and McGrath VL as compared to CMAC VL. The incidence of use of bougie was more with Macintosh direct laryngoscope due to the occurrence of unanticipated difficult airway.

None of the patients suffered any episodes of desaturation. Esophageal intubation was seen in 3 patients in group A (unanticipated difficult airway), while none was seen in the other two groups. Mild self-limiting mucosal bleed was seen in 20 patients in total and the distribution was comparable between the three groups [Table 1].

Discussion

Our study results demonstrate that the C-MAC performed better as compared to both McGrath VL and Macintosh DL in terms of improved first-attempt success rates and glottic views. Macintosh provided the fastest intubation while McGrath took the longest. In the present study, both the VLs provided significantly improved glottic views and higher first-attempt success rate as compared to the direct Macintosh laryngoscope.

C-MAC VL is one of the VLs that have vast safety and efficacy data in the management of difficult airway.[8-10,12,13] McGrath MAC is a relatively recent addition to the armamentarium of

Table 1: Demography data and intubation characteristics in the three study groups

Variable	Groups			*P*		
	A (*n*=60)	B (*n*=60)	C (*n*=60)	A vs B	A vs C	B vs C
Male/female (*n*)	32/28	37/23	33/27	0.46	1.00	0.55
ASA I/II	53/7	55/5	55/5	0.76	0.76	1.00
BMI (kg/m^2)	22.27±2.56	23.08±3.6	21.95±2.9	0.32	0.83	0.10
Successful first attempt Intubation; *n* (%)	54 (90)	60 (100)	59 (98.3)	0.027	0.114	1
CL Grade						
I	25 (41.6)	60 (100)	54 (90)	<0.0001	<0.0001	0.02
IIa	27 (45)	0 (0)	6 (10)			
IIb	5 (8.3)	0 (0)	0 (0)			
III	3 (5)	0 (0)	0 (0)			
Laryngoscopy time (s)	9.9±2.5	12.6±0.8	13.1±0.8	<0.0001	<0.0001	<0.0001
Intubation time (s)	24.4±12.1	28.3±2.0	37.3±5.8	<0.0001	<0.0001	<0.0001
Passes; *n* (%)						
1	42 (70)	31 (51.67)	12 (20)	0.119	<0.0001	0.0009
2	11 (18.3)	17 (28.3)	22 (36.6)			
3	7 (11.6)	12 (20)	21 (35)			
4	0 (0)	0 (0)	5 (8.3)			
Use of external laryngeal manipulation *n* (%)	23 (38.3)	0 (0)	15 (25)	<0.0001	0.116	<0.0001
Ease of laryngoscopy (easy/difficult; *n* (%))	55 (91.6%)/5 (8.3%)	60 (100%)/0 (0%)	58 (96.6%)/2 (3.3%)	0.06	0.44	0.49
Use of bougie as a rescue device; *n* (%)	3 (5)	0 (0)	0 (0)	0.24	0.24	*
Esophageal intubation; *n* (%)	3 (5)	0 (0)	0 (0)	0.24	0.24	*
Mucosal bleed; *n* (%)	10 (16.7%)	4 (6.7%)	6 (10%)	0.1	0.2	0.7

**Cannot be computed due to zero count. ASA: American Society of Anesthesiologists; BMI: body mass index; NS: non-significant*

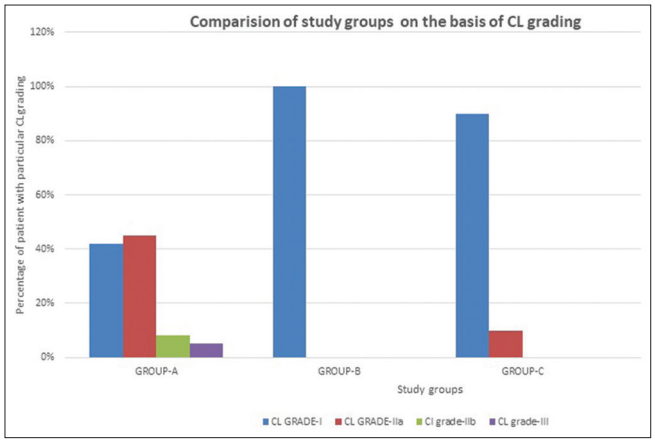

Figure 3: Graphical representation of the percentage of patients with different Cormack Lehane (CL) grading in three groups

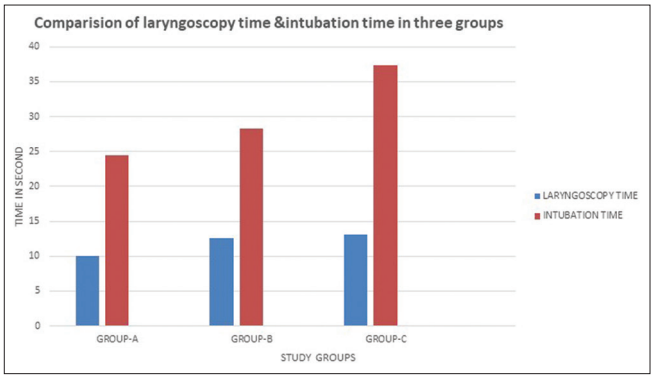

Figure 4: Graphical Comparison of laryngoscopy and intubation time in three study groups

anesthetists having a Macintosh type of disposable blade and is lightweight and portable. In our study, all the patients were intubated in a single attempt with CMAC VL, whereas 6 patients in the Macintosh DL group required a second attempt. Three out of these six patients had a CL grade of III and were intubated using OELM with the aid of a bougie. The increasing number of attempts has been found to correlate with the airway-related mishaps in the NAP4 audit on morbidity and mortality related to airway management. Considering that the first attempt success of CMAC VL and McGrath VL was significantly higher than Macintosh, VLs stand at an advantage over the DL in reducing the number of attempts. Sakles *et al.*[8] in a retrospective observational study found significantly higher success rates (98.9% vs 88.3%) with C-MAC as compared to Macintosh DL in normal airways in concordance with our study results.

Hodgetts *et al.*[14] in their study on comparison of CMAC-VL with Macintosh DL reported significantly higher laryngoscopy and intubation time with C-MAC VL as compared to the Macintosh group. They attributed the delay in intubation time with CMAC VL to the delay in "task execution", i.e. a good view of the larynx does not guarantee easy tracheal intubation. The results were in agreement with our study results.

Walker *et al.*[15] compared McGrath series-5 blade with Macintosh blade for routine endotracheal intubation

and found the duration of intubation to be significantly longer ($P < 0.001$) in the McGrath group, an observation which is similar to our study. The intubation time in their study was much higher as they employed the hyperangulated blade of McGrath, making it much more difficult to negotiate the ETT.

Ng *et al.*[16] recently compared McGrath MAC with C-MAC VL for endotracheal intubation in adult patients with a potentially difficult airway. Their study findings included shorter intubation times, fewer intubation attempts, and greater ease of intubation with the use of C-MAC VL as compared to McGrath VL. Our results coincided with the results of their study. On subjective grading of intubation difficulty, C-MAC resulted in easy tracheal intubation in all 60 patients in the present study, while Macintosh laryngoscope resulted in difficult intubation 5 patients and McGrath led to difficulty in intubating 2 patients. Considering that the airways were predicted to be normal, the difference can be clinically meaningful though statistically the difference was insignificant. C-MAC provides high-resolution views, and its anti-fogging mechanism helps maintain the clarity, thus explaining the greatest ease of intubation provided with this blade.

Shin *et al.*[17] compared DL, C-MAC VL, and McGrath VL in a randomized crossover Manikin study. It was concluded that McGrath VL and C-MAC VL resulted in a similar decrease in intubation time as compared to Macintosh DL when used in normal airways. This is not consistent with our study in which time to intubate was minimum with Macintosh DL and this difference may be due to the fact that theirs was a manikin study and operators were naïve.

The need for optimization manoeuvres and the intubation time was significantly less with C-MAC, while the glottic views were significantly better with C-MAC as compared to McGrath VL. The main reason for the superior intubation characteristics with C-MAC could be the lack of an anti-fog mechanism in McGrath VL whereby, in many cases due to the onset of fogging, the view worsened, and intubation took a longer time. The high-resolution view provided by C-MAC is another reason for improved views and faster intubation.

The number of passes to place the ETT was higher with VLs as compared to DL. The traditional skill of tube manipulation under direct vision in DL does not apply with VLs and hand-eye coordination is required for intubation.[18] The camera placed near the blade tip of the VL improves the glottic view, but while intubating, the tracheal tube is required to be directed more anteriorly, thereby increasing the intubation difficulty.[19,20] Also, midline insertion of the laryngoscope blade limits the space available in the oral cavity to manipulate the ETT with VLs.[20]

The strength of the study is that no study has compared two Macintosh-like VL blades, C-MAC and McGrath, with Macintosh laryngoscope for intubation in adults with the anticipated normal airway. McGrath VL has disposable blades and is cheaper than C-MAC but C-MAC performed better in terms of intubation time and glottic view. The findings become relevant and may help the anesthesiologist decide on the right device based on the cost involved and the unique advantages of the devices.

There are certain limitations to the study. First, because the study was conducted on airway devices with distinct make and appearance, blinding was not possible and, hence, bias is a possibility. However, the study outcome parameters were mostly objective and recorded by an independent observer, thereby minimizing the possibility of bias. Second, McGrath VL did not have an anti-fogging mechanism, which could have led to poor results with the device. We tried to overcome this problem by optimizing the OR temperature and dipping the blade in warm water 10 s before intubation. Third, only patients with an expected normal airway were evaluated and, thus, the results cannot be extrapolated to difficult airway cases. Fourth, various scoring systems like intubation difficulty score, Fremantle score, etc., were not used in our study. Lastly, only VLs with a Macintosh-like blade were evaluated and, thus, the results cannot be transferred to other kinds of VLs with different kinds of blades (e.g. hyperangulated blade, channelled blade).

Conclusion

C-MAC VL provided a superior first attempt success rate for endotracheal intubation when compared to Macintosh DL in routine intubations of adult patients posted for elective surgery. Both C-MAC and McGrath VLs provided a superior modified CL grade as compared to DL. C-MAC may be preferred over Macintosh and McGrath laryngoscopes for routine tracheal intubations in predicted normal airways to improve first attempt success rates and glottic views.

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Conflicts of interest
There are no conflicts of interest.

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