THE EFFICACY AND SAFETY OF THREE DIFFERENT TYPES OF VIDEOLARYNGOSCOPES IN ADULT PATIENTS WITH NORMAL AIRWAYS: A PROSPECTIVE RANDOMIZED CONTROLLED TRIAL

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Abstract

Background: While videolaryngoscopy can improve the visualization of the glottis during tracheal intubation compared with direct laryngoscopy, there is less clear evidence about their efficacy in terms of successful intubation and intubation time. The objective was to evaluate the efficacy and safety of three video laryngoscopes, among the most popular and well documented, as compared with Macintosh direct laryngoscopy.

Methods: One hundred and eighty-eight adult patients aged 18-70 years, ASA physical status 1 or 2, scheduled to undergo elective surgery were included in this prospective randomized controlled trial conducted by experienced anesthesiologists. Patients were randomly allocated in four groups; GlideScope (n=48), Airtraq (n=46), C-MAC D blade (n=45), and Macintosh direct

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laryngoscope (n=49). Those with increased risk for regurgitation and pulmonary aspiration, and history of gastro-oesophageal reflux, oropharyngeal surgery, known difficult intubation and pregnancy, were excluded from the study.

Results: Airtraq presented significantly shorter intubation time, compared with direct laryngoscopy, C-MAC D-blade and GlideScope. However, the three videolaryngoscopes had no significant difference in rate of successful first attempt, the number of intubation attempts, sore throat, dysphagia, and hemodynamic response to tracheal intubation (except for heart rate). However, Airtraq group had significantly higher oropharyngeal trauma and lower heart rate at fifth minute post-intubation. **Conclusions:** Despite the improved glottis view, videolaryngoscopes do not improve the success rate or reduce the number of intubations compared with Macintosh laryngoscopes among adult patients without expected difficult intubation. There are differential intubation times and risk of oropharyngeal trauma between videolaryngoscopes.

Introduction

In the vast majority of adult surgical patients, tracheal intubation using the Macintosh direct laryngoscope (DL) is a simple, safe, and uncomplicated technique. However, difficulties with tracheal intubation mainly associated with failure to see the larynx during attempts at intubation may commonly arise and impact patient safety.[1] Prediction of difficult airway management in daily clinical practice presents at best moderate sensitivity and specificity.[2,3] Additionally, recent evidence indicates that the majority (>90%) of such difficult intubations are not anticipated.[4]

In the last decade, videolaryngoscopy (VL) is increasingly used in tracheal intubation and is considered one of the major advances in clinical anesthesia in recent years.[5-9] In contrast to conventional DL, these new generations of devices are designed to provide an indirect view of the upper airway and an improved view of the glottic opening. The design of VL blades, have a steep angulation of more than 60° and this obviates the need for alignment of oral, pharyngeal and laryngeal axes for viewing the glottis. This is of major importance, especially in patients with suspected cervical injury or in patients with difficult airways.[9-13] There are several types of VL with variable features in regard to the type and curvature of blade, availability of stylet or built-in channel to guide endotracheal tube, position and quality of camera, position, size and quality of monitor, portability, disposability, and other ergonomic features.[5,14] In recent evidence VL was associated with a significantly better view of the glottis and reduced oropharyngeal trauma.[15] However, the authors could not identify evidence indicating that use of VL reduces the number of intubation attempts or the time required for intubation as compared with DL.[15]

The GlideScope (GS) Cobalt video laryngoscope (Verathon Medical, Bothell, WA), the Airtraq (AT) optical laryngoscope (Prodol Meditec S.A., Vizcaya, Spain) and the C-Mac D blade (CMD, Karl Storz, Tuttlingen, Germany) are among the most popular and well documented video-laryngoscopes that meet the standards of evidence called for by the ADEPT project in terms of adopting only evidence-based airway equipment.[16] The objective of the current prospective randomized controlled trial was to compare the efficacy and safety of the abovementioned VL devices, with the conventional DL acting as control group, in adult patients without anticipated difficult airways. Our primary study hypothesis was that there is no significant difference in intubation time between the 3 VL devices versus DL by experienced anesthetists.

Material and Methods

This study adhered to Good Clinical Practice quality standards and ethical guidelines defined by the Declaration of Helsinki. Study protocol approval as well as data and safety oversight was conducted by the Ethical Committee of King Abdullah International Medical Research Center (KAIRMC) (Riyadh, Saudi Arabia). Written informed consent was obtained from all participating subjects. The current study was conducted from December 2016 until March 2018 at King Abdulaziz Medical City in Riyadh (KAMC-R), an approximately 1000-bed tertiary care facility, providing healthcare services to about 750,000 Saudi

National Guard soldiers, employees and their families in Saudi Arabia. The number of patients undergoing VL during tracheal intubation is approximately 100 per month.

The study targeted adult patients aged 18-70 years with American Society of Anesthesiologists (ASA) 1 or 2, scheduled to undergo elective surgery that required tracheal intubation. Exclusion criteria were increased risk for regurgitation and pulmonary aspiration, history of gastrooesophageal reflux, oropharyngeal surgery, well known difficult intubation and pregnancy.

After protocol approval, 188 patients were randomly assigned to one of 4 groups: the GS, AT, CMD groups and the DL acting as the control group. Randomization was performed by an independent research assistant using a computer-generated random numbers. The randomization was concealed from the laryngoscopist in a sealed opaque envelope until after obtaining the informed consent from the patient. The assessor was impossible to blind as he was responsible for performing the intubation. All tracheal intubations in the study were performed by four experienced (>10 year) Board Certified anesthesiologists (SA for GS group, VD for AT group, AB for CMD group and MH for DL group), who each had experience of at least 100 tracheal intubations with each device.

Upon arrival to the holding area, patient and airway characteristics, such as gender, age, BMI, Mallampati score, inter-incisor distance/mouth opening and thyromental distance, were recorded. Standard monitoring was established after the patient entered the operating room including ECG, non-invasive blood pressure measurement and pulse oximetry. Induction of anesthesia was standardised (propofol 2 mg/kg, fentanyl 2 mcg/kg, and rocuronuim 0.6 mg/kg) and the vital signs (blood pressure, heart rate and oxygen saturation) were recorded at 3min after induction and were considered as the baseline measurement.

A single laryngoscopy with a Macintosh laryngoscope size 3 blade was performed by one of the investigators, to assess visualization of the glottis according to the Cormack and Lehane scale. Then another investigator, unaware of the Cormack and Lehane grade of the initial evaluation of the laryngoscopic view, performed laryngoscopy with the allocated laryngoscope, assessed the Cormack and Lehane grade and intubated the trachea. Laryngoscopy with GS and CMD were performed with the tip of the blade placed in the vallecula. Afterwards the styletted tube was passed to the right of the blade. Laryngoscopy with the AT was done with medial approach. After tracheal intubation was accomplished oropharyngeal trauma was identified and evaluated by an ENT surgeon, who examined the oral cavity, pharynx and larynx for signs of lacerations or bleeding provoked by the intubation.

The primary outcome endpoints included success of the first intubation attempt and time for tracheal intubation (TTI). TTI measurement was performed by an independent observer using digital chronometer and started after jaw opening when the allocated laryngoscope passed the patient's lips and stopped when it was removed from the mouth at the end of the intubation attempt. The correct placement was confirmed by capnography (EtCO2). Failed intubation was defined when the trachea could not be intubated within 60 seconds, more than 3 attempts were required, or in case of accidental esophageal intubation. Secondary outcome endpoints included overall success rate (i.e. success in the first or second attempt), the number of attempts at intubation, the Cormack–Lehane class achieved, hemodynamic response to tracheal intubation and the safety parameters. The latter included blood traces on the device and/or oropharyngeal trauma, sore throat and/or dysphagia. Trauma was recorded and categorized as follows: "0" for No blood on the device, No teeth –lip trauma, "1" for blood traces on the device or teeth – lip trauma, "2" for blood traces on the device and minimal traumatic pharyngeal injury, and "3" for blood on the device and traumatic pharyngeal lacerations. Oropharyngeal trauma was identified and evaluated by an ENT surgeon who examined the oral cavity, pharynx and larynx for signs of lacerations or bleeding provoked by the intubation. When the patients were moved to the Post Anesthesia Care Unit and again 24h postoperatively, they were interviewed by the independent research assistant to determine whether they were suffering from a sore throat or dysphagia, classified as none/mild/moderate/and severe. Hemodynamic data (BP, HR) and SpO2, were recorded at 1,3 and 5min after tracheal intubation.

Statistical Analysis

Sample size estimation was based on a univariate single group repeated measures analysis of variance for the time to intubation measurements. Assuming a likely difference able to detect an effect size of 1.5 seconds in mean times to intubation, an a priori power analysis revealed that a group size of n=45 was needed to detect a difference with a power of 0.9 at an α-level of 0.05.

Intention-to-treat analysis according to randomization was performed. Categorical data were presented as frequencies and percentages while continuous data were presented as mean and standard deviation (SD) or median and interquartile range (IQR). Data were checked for normality. Significant differences of continuous variables between the four groups were examined using one-way analysis of variance (ANOVA) when data were normally distributed and Kruskal-Wallis test when data were not normally distributed. *Post hoc* pairwise comparisons between any of the 3 VL groups against conventional DL were examined using Dunnett test when data were normally distributed and using Mann-Whitney test when data were not normally distributed. In the latter case, p-values were adjusted for multiple comparisons using Holm–Bonferroni method. *Post hoc* pairwise comparisons between any 2 of the 4 groups were examined using Bonferroni test when data were normally distributed and using Mann-Whitney test when data were not normally distributed. In the latter case, p-values were adjusted for multiple comparisons using Holm–Bonferroni method. Significant changes in vital signs over time were examined using repeated analysis ANOVA, and Bonferroni or Dunnett tests for post hoc pairwise comparisons. Significant differences of categorical variables between the four groups as well as pairwise comparisons were examined using chi-square test or Fisher exact test (as appropriate). Adjustment of intubation time was done using general linear model after log-transforming of the intubation time. Adjustment of categorical outcomes was done using logistic regression models. Correlation between Mallampati Class and Cormack-Lehane score were done using Spearman correlation. All P-values were two-tailed. P-value <0.05 or adjusted p-values (of Holm–Bonferroni method) were considered significant. SPSS software (release 24.0, Armonk, NY: IBM Corp) was used for all statistical analyses.

Results

A total of 188 patients were included in the study. They were distributed in roughly 4 equal groups; GS (n=48), AT (n=46), CMD (n=45) and DL (n=49). Table 1 shows the baseline characteristics of the study patients. Age, gender, body mass index and vital signs (systolic, diastolic, and mean blood pressure and heart rate) were not significantly different between the groups. Thyromental distance and inter-incisor distance were significantly different between groups (p<0.001 for each). Post-hoc tests showed that thyromental distance was significantly shorter in AT compared with the other 3 groups. Post-hoc tests showed that inter-incisor distance was significantly longer in GS and AT compared with CMD or DL groups. Mallampati Class and Cormack-Lehane score were significantly different between groups (p<0.001 for each). Mallampati Class was significantly higher in AT compared with the other 3 groups. Cormack-Lehane score was significantly higher in DL compared with the other 3 groups. Mallampati Class was positively and significantly correlated with Cormack-Lehane score (Spearman's Rho=0.169, p=0.021).

Table 2 shows the study outcomes by groups. Intubation time was significantly different (p<0.001) between groups, being longest in CMD and shortest in AT. Compared with DL, intubation times with CMD and GS were significantly longer while AT was significantly shorter. Fairly similar findings were observed after the intubation time was adjusted for relevant differences at baseline (Mallampati class, thyromental distance, and inter-incisor distance). Compared with DL, the three VL had no significant difference in rate of successful first attempt or the number of intubation attempts. For all patients, 11.2% had oropharyngeal trauma including bleeding (10.2%), pharyngeal laceration (3.7%), and none dental damage. Compared with DL, AT group had significantly higher oropharyngeal trauma (p=0.007). The difference remained after adjustment of relevant differences at baseline; Mallampati class and thyromental distance (odds ratio 14.2, p=0.022). For all patients, 31.7% had

Table 1

Baseline characteristics of the study patients by group

	GS n=48	AT n=46	CMD n=45	DL n=49	p1- value	p2- value	p3- value
Age (years)							
Mean±SD	37.5±10.4	38.3±13.4	34.2±12.6	38.4±12.0	0.312		
≤30	11 (23.4%)	13 (28.3%)	17 (37.8%)	12 (24.5%)	0.408		
31-40	19 (40.4%)	12 (26.1%)	16 (35.6%)	16 (32.7%)			
>40	17 (36.2%)	21 (45.7%)	12 (26.7%)	21 (42.9%)			
Gender							
Male	17 (35.4%)	20 (43.5%)	16 (35.6%)	19 (38.8%)	0.840		
Female	31 (64.6%)	26 (56.5%)	29 (64.4%)	30 (61.2%)			
Height (cm)	162.2±8.9	164.0±10.3	161.4±9.0	161.7±8.6	0.561		
Weight (kg)	76.5±17.7	79.3±17.9	75.3±17.9	74.0±15.2	0.488		
BMI Mean±SD	29.2±6.9	29.9±8.0	29.0±6.5	28.6±6.9	0.823		
Non-obese (<30)	27 (56.3%)	24 (52.2%)	26 (57.8%)	30 (61.2%)	0.846		
Obese (≥30)	21 (43.8%)	22 (47.8%)	19 (42.2%)	19 (38.8%)			
Hemodynamic data							
Systolic BP (mmHg)	106.2±19.6	114.3±19.0	108.2±15.6	109.8±15.3	0.151		
Diastolic BP (mmHg)	63.9±15.4	64.9±12.8	59.6±10.9	62.5±12.3	0.250		
MAP (mmHg)	80.5±15.5	85.1±15.0	79.0±10.6	80.4±12.1	0.167		
Heart rate (beat/min)	75.3±12.3	79.8±15.3	78.0±16.9	79.6±14.7	0.429		
Thyromental distance (mm)	75.8±7.1	66.1±7.1	70.9±9.6	72.4±7.6	<0.001	GS/AT GS/CMD AT/CMD AT/DL	AT
Inter-incisor distance (mm)	44.4±6.9	46.5±5.8	40.6±6.1	41.2±6.5	<0.001	GS/CMD AT/CMD AT/DL	GS /AT
Mallampati Class							
1	29 (60.4%)	13 (28.3%)	26 (57.8%)	33 (67.3%)	<0.001	GS/AT AT/CMD AT/DL	AT
2	18 (37.5%)	24 (52.2%)	19 (42.2%)	12 (24.5%)			
3	1 (2.1%)	9 (19.6%)	0 (0.0%)	4 (8.2%)			
Cormack-Lehane score							
Full view of glottis	48 (100.0%)	46 (100.0%)	42 (95.5%)	28 (57.1%)	<0.001	GS/DL AT/DL CMD/DL	GS/AT/CMD
Partial view of glottis	0 (0.0%)	0 (0.0%)	2 (4.5%)	13 (26.5%)			
Only epiglottis seen	0 (0.0%)	0 (0.0%)	0 (0.0%)	8 (16.3%)			

p1-value detected any significant differences between the 4 groups.

p2-value detected pairwise significant differences between any 2 of the 4 groups.

p3-value detected significant differences between any of the 3 VL groups against DL.

GS: GlideScope, AT: Airtraq, CMD: C-MAC D blade, DL: Direct laryngoscopy.

BMI: body mass index, BP: blood pressure, MAP: mean arterial pressure.

Table 2

Outcomes among the study patients by group

	GS n=48	AT n=46	CMD n=45	DL n=49	p1- value	p2- value	p3- value
TTI (sec)							
Unadjusted, mean±SD	14.9±6.2	10.4±5.9	17.2±11.4	13.5±9.0	<0.001	GS/AT AT/CMD CMD/DL	GS/AT/CMD
Unadjusted, median (IQR)	13.0 (10.1-17.8)	8.4 (6.7-12.9)	13.5 (10.1-18.5)	10.8 (8.4-16.2)	<0.001	GS/AT AT/CMD CMD/DL	GS/AT/CMD
Adjusted, mean±SD *	15.4±7.5	9.7±7.3	15.4±7.3	12.3±7.6	<0.001	GS/AT AT/CMD	GS/AT/CMD
Successful first attempt							
No	0 (0.0%)	1 (2.2%)	4 (8.9%)	2 (4.1%)	0.101		
Yes	48 (100.0%)	45 (97.8%)	41 (91.1%)	47 (95.9%)			
Number of attempts	1.00±0.00	1.02±0.15	1.09±0.29	1.04±0.20	0.139	GS/CMD	
Oropharyngeal trauma**							
No	43 (89.6%)	37 (80.4%)	38 (86.4%)	48 (98.0%)	0.036		AT
Yes	5 (10.4%)	9 (19.6%)	6 (13.6%)	1 (2.0%)			
Bleeding							
No	43 (89.6%)	38 (82.6%)	39 (88.6%)	48 (98.0%)	0.074		AT
Yes	5 (10.4%)	8 (17.4%)	5 (11.4%)	1 (2.0%)			
Bleeding degree							
Mild	3 (60.0%)	5 (62.5%)	5 (100.0%)	1 (100.0%)	0.510		
Moderate	2 (40.0%)	3 (37.5%)	0 (0.0%)	0 (0.0%)			
Severe	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)			
Pharyngeal laceration							
No	47 (97.9%)	41 (89.1%)	43 (97.7%)	49 (100.0%)	0.038		
Yes	1 (2.1%)	5 (10.9%)	1 (2.3%)	0 (0.0%)			
Dental damage							
No	48 (100.0%)	46 (100.0%)	44 (100.0%)	49 (100.0%)	-		
Yes	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)			
Sore throat							
No	32 (66.7%)	28 (62.2%)	30 (69.8%)	35 (74.5%)	0.638		
Yes	16 (33.3%)	17 (37.8%)	13 (30.2%)	12 (25.5%)			
Dysphagia							
No	39 (81.3%)	34 (75.6%)	35 (81.4%)	42 (89.4%)	0.389		
Yes	9 (18.8%)	11 (24.4%)	8 (18.6%)	5 (10.6%)			
Improvement of Cormack-Lehane score							
None	29 (60.4%)	17 (37.0%)	23 (52.3%)	---	0.169		
One class better	16 (33.3%)	23 (50.0%)	19 (43.2%)	---			
Two class better	3 (6.3%)	6 (13.0%)	2 (4.5%)	---			

p1-value detected any significant differences between the 4 groups.

p2-value detected pairwise significant differences between any 2 of the 4 groups.

p3-value detected significant differences between any of the 3 VL groups against DL.

TTI: Time for tracheal intubation, GS: GlideScope, AT: Airtraq, CMD: C-MAC D blade, DL: Direct laryngoscope.

* Adjusted for the Mallampati Class, thyromental distance, and inter-incisor distance.

** Oropharyngeal trauma included bleeding, pharyngeal laceration and dental damage.

sore throat and 18.0% had dysphagia. Compared with DL, the three VL had no significant difference in both sore throat and dysphagia. Compared with DL, there was 39.6% to 63.0% improvement of Cormack-Lehane score in the 3 VL groups. However, the improvement was not significantly different between groups.

Figure 1 shows the changes in vital signs overtime by groups. The trends of systolic, diastolic, and mean blood pressure in all patients showed approximately 10% increase after the first minute, followed by steady decrease at the third and fifth minutes (to approximately 6% reduction from baseline level). While the trends (differences over time) were significant in all groups ($p<0.001$ for each), there were no significant differences between the groups at any point in time. The heart rate in all patients showed approximately 14% increase after the first minute, followed by slight decrease at the third and fifth minutes (but remained approximately 8% above baseline level). This was true in all groups but the AT group that had -2.2±11.0 mmHg at the fifth minute. Therefore, AT group had significantly lower heart rate at the fifth minute than CMD and DL groups. Additionally, the heart rate trends were significant in all groups ($p<0.001$ for each).

Discussion

The current study compared three different types of well documented VL devices (GS, AT and CMD) versus conventional DL in a randomized design, among adult patients undergoing elective surgery. To our knowledge, this is the first clinical study comparing these VL devices in between as well as versus conventional DL in adult patients without anticipated difficult airways.

Consistent with the body of literature, the VL devices included in the current study markedly improved (40%- 63%) the glottic view in Cormack-Lehane score.[15,17-21] We found that the success rate of the first intubation attempt and overall success rate were not different between groups. Similar to the current finding, meta-analyses that pooled success rate data from randomized studies examining different or individual VL devices found no difference in success rate compared with DL.[15,20.21]

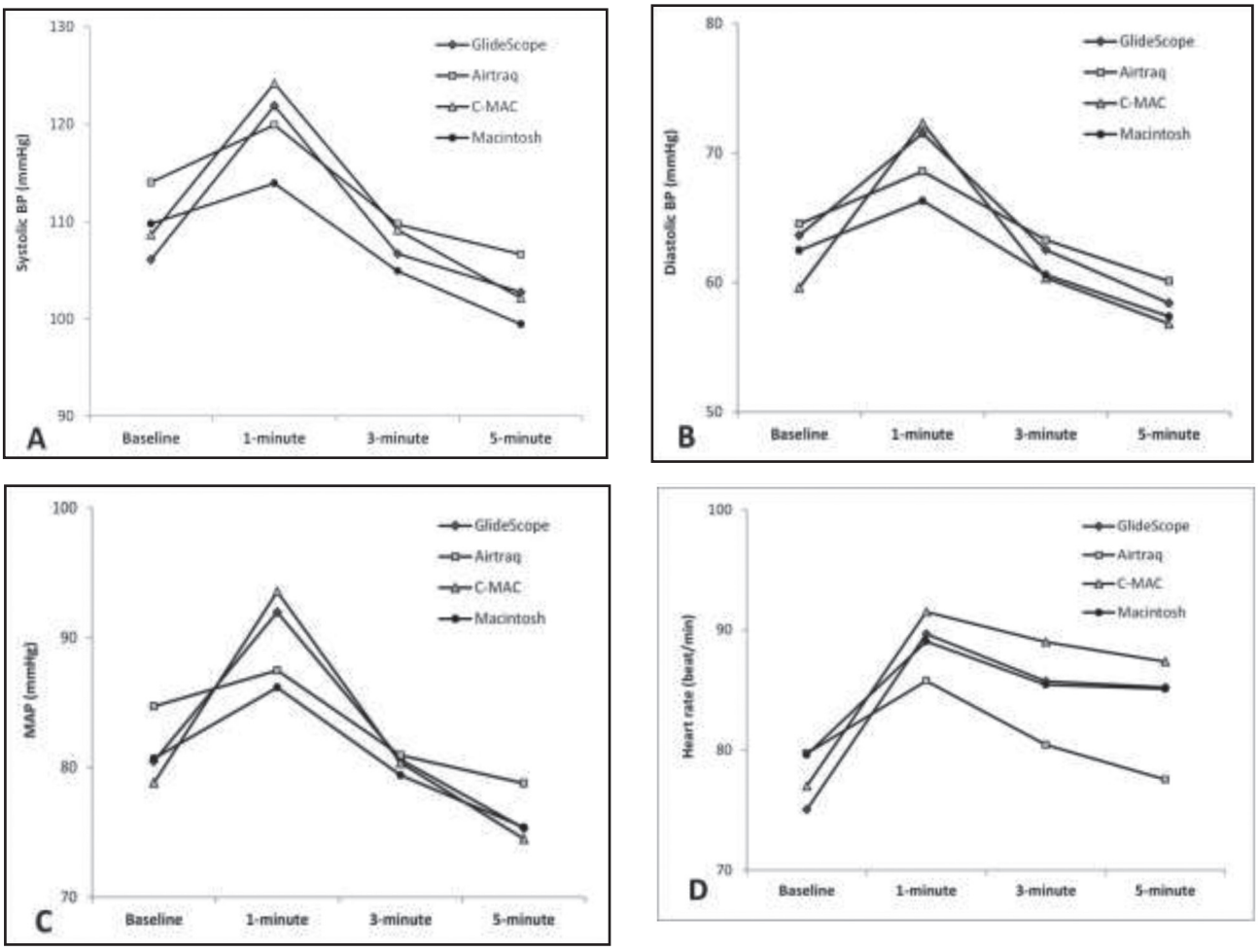
Additionally, another meta-analysis reported no difference in first intubation attempt success rate in GS and C-MAC studies but higher success rate in AT studies compared with DL.[18] Notably, current evidence indicated that the rate of successful first attempt was much higher in VL used in patients with difficult intubation.[11,13,15] Furthermore, the number of intubation attempts in VL and DL was not different in both current and previous studies.[15] The current study was conducted by experienced anesthesiologists in airway management among patients with normal or difficult airways.[22,23] This may explain the higher success rate observed in the current study compared with the majority of previous studies.[15,18]

It has been suggested that previously claimed benefits of VL on TTI is mainly seen among inexperienced laryngoscopists and in patients with expected difficult intubation.[7,10-13,17] This was demonstrated in a recent meta-analysis that found better efficacy parameters including TTI in VL compared with DL in obese patients.[24] In our study we found that TTI was shorter in AT group compared with GS and CMD groups in both adjusted and non-adjusted analysis. The longer average TTI in the GS and CMD groups may be related to the technique especially when a bulky VL device is required to manipulate the stylet and endotracheal tube through the vocal cords. Likewise, shorter intubation time in AT may be related to the presence of built-in side channel to guide the tracheal tube, which is preloaded before the start of intubation. Similar to the current finding, AT was associated with significantly shorter TTI in a meta-analysis that pooled data from 17 randomized studies examining different VL devices.[18] On the other hand, two meta-analyses that pooled data from 18 randomized studies examining C-MAC and 17 randomized studies examining GS found no difference in TTI as compared with DL,[20,21] and one study reported that the VL device used presented inferior efficacy parameters compared with DL.[25] Furthermore, a recent meta-analysis that pooled data from 37 randomized studies among adult patients could not estimate the impact of different VL on TTI.[15] This was acknowledged to the high variability in the definition and presentation of TTI and very high level of heterogeneity between the studies.[15] Consisted to this, we found that TTI for all VL devices in the current study was much shorter than observed in the majority of previous studies.[18,20,21]

Oropharyngeal trauma in GS and CMD groups

Fig. 1

Changes in hemodynamic data overtime (baseline, 1-min, 3-min, 5-min) among the study patients by group. A; changes of systolic blood pressure (mmHg). B; changes of diastolic blood pressure (mmHg). C; changes of mean arterial pressure (MAP) (mmHg). D; changes of heart rate (beat/min).



were not different from DL in both current and previous studies.[18,20] However, it was higher in AT than DL group, although mild in most cases (62.5%) limited to blood traces on the device. This finding should be cautiously interpreted as there were no concomitant differences between the groups in regard to sore throat and dysphagia, which are frequently used as subjective surrogate markers of oropharyngeal trauma.[15] Interestingly, AT group in this study had the highest Mallampati class at baseline. Despite the better traumatic profile of VL in recent meta-analyses,[15,17] previous studies have reported that VL may put the patients at significantly greater risk for oropharyngeal trauma compared to DL.[26,27]

We found that the AT reduced the hemodynamic response to tracheal intubation in both current and previous recent study.[28] This could be attributed to the design of VL blades that leads to minimal pressure exerted on the upper airway structure during VL, which can potentially reduce the hemodynamic response.[29-30]

Currently, there is strong evidence that VL improves the view at laryngoscopy and improves intubation success.[4-8,11-15] However, its use is relatively uncommon and limited mainly as a rescue technique or in patients with difficult airways.[10-13,31-34] Although most support that there is inconclusive evidence indicating that VL should replace DL in patients with normal or difficult airways, several authors have suggested that VL could be used as the default intubation technique, with removal of standard DL from routine use.[5-7,35-37]

Study Limitations

First, it was not possible to blind the intubator to the device, nor to blind assessors of process measures. Lack of blinding may represent a potential source of observer bias and tends to overestimate treatment effect estimates.[38] Additionally, lack of blinding may affect the performance as a result of the Hawthorne effect,[39] when individuals know they are being observed and therefore change their behavior. Second, the single laryngoscopy with a Macintosh laryngoscope size 3 blade that was performed by one of the investigators to assess visualization of the glottis according to the Cormack and Lehane scale, may lead to some degree of oropharyngeal trauma and may represent a potential source of observer bias. Third, the current study was conducted by experienced anesthesiologists in airway management among patients with normal or difficult airways. Therefore, our results may not apply to others less experienced anesthesiologists. Fourth, the definition of time for tracheal intubation (TTI) in our study is different than others. This makes our results non comparable and creates a level of statistical heterogeneity, necessitating that future airway research should be performed with standardized and universally agreed outcomes and definitions of those outcomes.[40]

In conclusion, despite the improved glottis view, VL does not improve the success rate or reduces the number of attempts at intubation compared with DL among adult patients without anticipated difficult airways undergoing elective surgery. The current data showed prolonged intubation time in CMD and GS groups and shorter intubation time in AT group. The latter had also higher risk of oropharyngeal trauma but lower impact on heart rate. Sore throat and dysphagia were not different between VL and DL.

References

1. Cook TM, Woodall N, Frerk C. Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. Br J Anaesth. 2011;106: 617-31
2. Shiga T, Wajima Z, Inoue T, Sakamoto A. Predicting difficult intubation in apparently normal patients: a meta- analysis of bedside screening test performance. Anesthesiology. 2005;103:429-37.
3. Nørskov AK, Rosenstock CV, Wetterslev J, Astrup G, Afshari A, Lundstrøm LH. Diagnostic accuracy of anaesthesiologists' prediction of difficult airway management in daily clinical practice: a cohort study of 188 064 patients registered in the Danish Anaesthesia Database. Anaesthesia 2015;70:272-81
4. Kleine-Brueggeney M, Greif R, Schoettker P, Savoldelli GL, Nabecker S, Theiler LG. Evaluation of six videolaryngoscopes in 720 patients with a simulated difficult airway: a multi-centre randomized controlled trial. *Br J Anaesth*. 2016;116:670–9
5. Kelly FE, Cook TM. Seeing is believing: getting the best out of videolaryngoscopy. British Journal of Anaesthesia 2016;117: i9–13
6. Zaouter C, Calderon J, Hemmerling TM. Videolaryngoscopy as a new standard of care. *Br J Anaesth*. 2015;114:181–3
7. Aseri S, Ahmad H, Vallance H. Video laryngoscopy improves endotracheal intubation training for novices. Br J Anaesth. 2015; 115:133
8. Healy DW, Maties O, Hovord D, Kheterpal S. A systematic review of the role of videolaryngoscopy in successful orotracheal intubation. BMC Anesthesiol 2012; 12: 32
9. Turkstra T, Craen R, Pelz D, Gelb A. Cervical spine motion: a fluoroscopic comparison during intubation with lighted stylet, GlideScope, and Macintosh laryngoscope. Anesth Analg 2005; 101: 910–5
10. Maassen R, Lee R, Hermans B, Marcus M, van Zundert A. A comparison of three videolaryngoscopes: the Macintosh laryngoscope blade reduces, but does not replace, routine stylet use for intubation in morbidly obese patients. Anesth Analg 2009; 109: 1560–5
11. Stroumpoulis K, Pagoulatou A, Violari M, et al. Videolaryngoscopy in the management of the difficult airway: a comparison with the Macintosh blade. Eur J Anaesthesiol. 2009; 26: 218–22.
12. Serocki G, Neumann T, Scharf E, Doerges V, Cavus E. Indirect videolaryngoscopy with C-MAC D-Blade and GlideScope: a randomized, controlled comparison in patients with suspected difficult airways. Minerva Anestesiol. 2013; 79: 121–9.
13. Aziz MF, Healy D, Kheterpal S, Fu RF, Dillman D, Brambrink AM. Routine clinical practice effectiveness of the Glidescope in difficult airway management: an analysis of 2004 Glidescope intubations, complications and failures from two institutions. *Anesthesiology*. 2011; 114: 34–41
14. Niforopoulou P, Pantazopoulos I, Demestiha T, Koudouna E, Xanthos T. Video-laryngoscopes in the adult airway management: a topical review of the literature. *Acta Anaesthesiol Scand* 2010, 54:1050-61.
15. Lewis SR, Butler AR, Parker J, Cook TM, Schofield-Robinson OJ, Smith AF. Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation. A Cochrane Systematic Review. Br J Anaesth. 2017;119:369-83
16. Pandit JJ, Popat MT, Cook TM, et al. The Difficult Airway Society 'ADEPT' guidance on selecting airway devices: the basis of a strategy for equipment evaluation. Anaesthesia 2011; 66: 726-37
17. Pieters BM, Mass EH, Knape JT, van Zundert AA. Videolaryngoscopy vs. direct laryngoscopy by experienced anaesthetists in patients with known difficult airways: a systematic review and meta-analysis. Anaesthesia. 2017;72:1532-41
18. Suppan L, Tramer MR, Niquille M, Grosgurin O, Marti C: Alternative intubation techniques vs Macintosh laryngoscopy in patients with cervical spine immobilization: systematic review and meta-analysis of randomized controlled trials. *Br J Anaesth* 2016, 116:27-36
19. Pott LM, Murray WB: Review of videolaryngoscopy and rigid fiberoptic laryngoscopy. *Curr Opin Anaesthesiol* 2008, 21:750-8
20. Hoshijima H, Mihara T, Maruyama K, Denawa Y, Mizuta K, Shiga T, Nagasaka H: C-MAC videolaryngoscope versus Macintosh laryngoscope for tracheal intubation: A systematic review and meta-analysis with trial sequential analysis. *J Clin Anesth* 2018, 49:53-62
21. Griesdale DE, Liu D, McKinney J, Choi PT: Glidescope(R) video-laryngoscopy versus direct laryngoscopy for endotracheal intubation: a systematic review and meta-analysis. *Can J Anaesth* 2012, 59:41-52
22. Dimitriou V, Zogogiannis I, Douma A, Pentilas N, Liotiri D, Wachtel MS, Karakitsos D. Comparison of standard polyvinyl chloride tracheal tubes and straight reinforced tracheal tubes for tracheal intubation through different sizes of the Airtraq laryngoscope in anesthetized and paralyzed patients: a randomized prospective study. Anesthesiology 2009;111:1265-70
23. Awake tracheal intubation using the Airtraq laryngoscope: a case series. Dimitriou V, Zogogiannis I, Liotiri D. Acta Anaesthesiol Scand. 2009;53:964-7
24. Hoshijima H, Denawa Y, Tominaga A, Nakamura C, Shiga T, Nagasaka H: Videolaryngoscope versus Macintosh laryngoscope for tracheal intubation in adults with obesity: A systematic review and meta-analysis. *J Clin Anesth* 2018, 44:69-75
25. Abdallah R, Galway U, You J, Kurz A, Sessler DI, Doyle DJA. Randomized comparison between the Pentax AWS video laryngoscope and the Macintosh laryngoscope in morbidly obese patients. Anesth Analg 2011; 113: 1082–7.
26. Greer D, Marshall KE, Bevans S, Standlee A, McAdams P, Harsha W. Review of videolaryngoscopy pharyngeal wall injuries. Laryngoscope 2017;127:349-53
27. Lange M, Frommer M, Redel A et al. Comparison of the Glidescope and Airtraq optical laryngoscopes in patients undergoing direct microlaryngoscopy. Anaesthesia. 2009;64:323-8
28. Hoshijima H, Maruyama K, Mihara T, Mieda T, Shiga T, Nagasaka H: Airtraq reduces the hemodynamic response to tracheal intubation using single-lumen tubes in adults compared with the Macintosh laryngoscope: A systematic review and meta-analysis of randomized control trials. *J Clin Anesth* 2018, 47:86-94
29. Carassiti M, Biselli V, Cecchini S, Zanzonico R, Schena E, Silvestri S, Cataldo R: Force and pressure distribution using Macintosh and GlideScope laryngoscopes in normal airway: an in vivo study. *Minerva Anestesiol* 2013, 79(5):515-24
30. Lee RA, Van Zundert AAJ, Maassen RLJG, et al. Forces applied to the maxillary incisors during video-assisted intubation. Anesth Analg 2009; 108: 187–91.
31. Malin E, Montblanc JD, Ynineb Y, Marret E, Bonnet F. Performance of the Airtraq laryngoscope after failed conventional tracheal

intubation: a case series. Acta Anaesthesiol Scand 2009; 53: 858-63
32. Noppens RR, Mobus S, Heid F, Schmidtmann I, Werner C, Piepho T. Evaluation of the McGrath Series 5 Videolaryngoscope after failed direct laryngoscopy. Anaesthesia 2010; 65: 716-20
33. Cook T, Boniface N, Seller C, et al. Universal video-laryngoscopy: a structured approach to conversion to videolaryngoscopy for all intubations in an anaesthetic and intensive care department. Br J Anaesth 2018; 120: 172-9
34. Cortellazzi P, Minati L, Falcone C, Lamperti M, Caldiroli D. Predictive value of the El-Ganzouri multivariate risk index for difficult tracheal intubation: a comparison of Glidescope videolaryngoscopy and conventional Macintosh laryngoscopy. Br J Anaesth 2007; 99: 906-11
35. Paolini JB, Donati F, Drolet P. Review article: videolaryngoscopy: another tool for difficult intubation or a new paradigm in airway management? *Can J Anesth*. 2013; 60: 184–91
36. Schulz KF, Chalmers I, Hayes RJ, Altman DG. Empirical evidence of bias. Dimensions of methodological quality associated with estimates of treatment effects in controlled trials. JAMA 1995; 273: 408–12
37. Holden JD. Hawthorne effects and research into professional practice. J Eval Clin Pract 2001; 7: 65– 70
38. Jammer I, Wickboldt N, Sander M, et al. Standards for definitions and use of outcome measures for clinical effectiveness research in perioperative medicine: European Perioperative Clinical Outcome (EPCO) definitions: A statement from the ESA-ESICM joint taskforce on perioperative outcome measures. Eur J Anaesthesiol 2015;32:88-105