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Original Contribution

Comparison of three video laryngoscopy devices to direct laryngoscopy for intubating obese patients: a randomized controlled trial☆,☆☆

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Abstract
Study objective: To compare three different video laryngoscope devices (VL) to standard direct laryngoscopy (DL) for tracheal intubation of obese patients undergoing bariatric surgery. Hypothesis: VL (vs DL) would reduce the time required to achieve successful tracheal intubation and improve the glottic view.
Design: Prospective, randomized and controlled.
Setting: Preoperative/operating rooms and postanesthesia care unit.
Patients: One hundred twenty-one obese patients (ASA physical status I-III), aged 18 to 80 years, body mass index (BMI) >30 kg/m^2 undergoing elective bariatric surgery.

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Intervention: Patients were prospectively randomized assigned to one of 4 different airway devices for tracheal intubation: standard Macintosh (Mac) blade (DL); Video-Mac VL; Glide Scope VL; or McGrath VL.
Measurements: After performing a preoperative airway evaluation, patients underwent a standardized induction sequence. The glottic view was graded using the Cormack Lehane and percentage of glottic opening (POGO) scoring systems at the time of tracheal intubation. Times from the blade entering the patient's mouth to obtaining a glottic view, placement of the tracheal tube, and confirmation of an end-tidal CO_2 waveform were recorded. In addition, intubation attempts, adjuvant airway devices, hemodynamic changes, adverse events, and any airway-related trauma were recorded.
Main results: All three VL devices provided improved glottic views compared to standard DL ($p < 0.05$). Video-Mac VL and McGrath also significantly reduced the time required to obtain the glottic view. Video-Mac VL significantly reduced the time required for successful placement of the tracheal tube (vs DL and the others VL device groups). The Video-Mac and GlideScope required fewer intubation attempts ($P< .05$) and less frequent use of ancillary intubating devices compared to DL and the McGrath VL.
Conclusion: Video-Mac and GlideScope required fewer intubation attempts than standard DL and the McGrath device. The Video-Mac also significantly reduced the time needed to secure the airway and improved the glottic view compared to standard DL.

1. Introduction

More than two-thirds of adults in the United States are overweight or obese, and an increasing percentage are morbidly obese [1]. Patients with a body mass index (BMI) over 40 (or BMI of 35 with one additional co-morbidity) are considered candidates for bariatric surgery [2]. Although many would agree that obesity *per se* is not a risk factor for difficult intubation [3], there are many well known obesity-related challenges in airway management including difficulty with mask ventilation, more frequent and rapid oxygen desaturation, increased oxygen consumption, and increased sensitivity to the respiratory depressant effects of anesthetic and analgesic drugs [4]. However, other authors maintain that difficult or failed intubation in obese patients is more common than patients who are not obese [5]. For example, Shiga et al [6] reported the incidence of difficult intubation in the obese population with a BMI of greater than 30 was 15.8% compared to 5.8% in the general population; while Juvin et al [5] reported 15.5% compared to 2.2%. Others [5,7] suggest that it is more difficult to perform tracheal intubation or obtain a clear view of the glottis in morbidly obese patients.

Recent publications have reported the superiority of video-laryngoscopy (VL) over direct laryngoscopy (DL) with respect to obtaining the glottic view, less associated local airway trauma, and maintaining oxygen desaturation when used for intubation of obese patients [2,4,8–10]. However, other studies report an increased intubation time and higher intubation failure rates with VL compared to standard DL [11,12]. We hypothesized that use of VL devices would decrease intubation time and improve the glottic view compared to standard DL. The secondary objective was to determine if there were any significant differences among the three VL devices and DL with respect to adverse events.

2. Materials and methods

After obtaining IRB approval at Cedars Sinai Medical Center in Los Angeles (IRB Protocol: Pro00019199, Clinical trials registration http://www.clinicaltrials.gov NCT01114945 April 2010), consenting patients satisfying the inclusion criteria were enrolled from May 2010 to February 2012. The inclusion criteria were as follows: participants scheduled for elective bariatric surgery and, 18–80 years of age with a BMI >30 kg/m^2. Exclusion criteria included patients with a history of facial abnormalities, previous oral-pharyngeal cancer or reconstructive surgery, cervical spine injury, patients who required an awake fiber optic intubation, emergency operations, severe mental disorder, pregnant patients, and those with a history of a difficult intubation. This study complied with all 25 items on the Consort 2010 checklist (Appendix I).

After obtaining written informed consent, 121 obese patients undergoing bariatric surgery (e.g., laparoscopic gastric band placement, laparoscopic Roux-EN-Y gastric bypass laparoscopic) requiring general endotracheal anesthesia were randomly assigned to one of 4 study groups using a 1:1 allocation ratio using Minitab 12 computer software. The 4 intubating device groups included: Group 1 (Control): DL utilizing a standardized Macintosh (Mac) blade; Group 2: Video-Mac video laryngoscope (VL); Group 3: GlideScope VL (GlideScope GVL and Cobalt-Reusable); and Group 4: McGrath VL (Series 5). Blade size 3 or 4 was utilized in the 4 intubating device groups, and determined by the attending anesthesiologist. The name of the assigned intubation device was placed in sealed envelope and given to the participating anesthesiologist after they obtained informed consent and completed the patient's airway evaluation.

All anesthesiologists performing the tracheal intubations had been previously trained using all three VL devices (with a minimum of 20 intubations with each device). The airway assessment of each patient was performed by the attending anesthesiologist in the preoperative holding area while the patient was full awake sitting upright. The Mallampati score was recorded using the modified Mallampati scoring system [13]. Once the preoperative airway evaluation was completed, a sealed envelope with a matching identification number was opened to identify the treatment group. Patients were blinded as to the intubating device. A styleted Mallinckrodt Hi-Lo oral/nasal tracheal tube cuffed Murphy eye tube from Covidien was used for tracheal intubation. The tracheal tube size and laryngoscope blade size were selected by the attending anesthesiologist.

Patients were transported to the operating room, positioned supine and the upper body was ramped using folded blankets. Monitoring devices included an automatic blood pressure cuff, three-lead electrocardiogram, capnograph, pulse oximeter, and an EEG bispectral (BIS) index monitor. All patients were pre-oxygenated with 100% oxygen for 3 to 5 min prior to induction of anesthesia using a facemask to achieve a baseline O_2 saturation greater than 98%. A standardized induction technique consisting of propofol 2 to 2.5 mg/kg IV, lidocaine 1 to 1.5 mg/kg IV, and succinylcholine 1 to 1.5 mg/kg IV was utilized. The timing measurements began once the laryngoscope blade was placed in the patient's mouth and ended when an end-tidal CO_2 tracing was detected. All patients were manually ventilated with 100% oxygen following the onset of neuromuscular blockade (ie, loss of responsiveness to train of 4 stimulations [TOF]) as determined using peripheral nerve stimulation of the ulnar nerve at the wrist. Supplemental bolus doses of propofol were administered to increase the depth of anesthesia if necessary. The attending anesthesiologist rated the glottic visualization as the tracheal tube was being inserted using the Cormack Lehane [14] and percentage of glottis opening (POGO) scoring systems. The Cormack-Lehane grading system [14] and the POGO score [15] evaluate the glottic view during tracheal intubation using a classification of 1/2/3/4 and a score of 0% to 100%, respectively. The POGO score denote visualization of the entire glottic opening from the anterior commissure to the posterior cartilages, and a score of 0% denotes inability to visualize any part of the glottic opening [15].

The primary end points were that the three VL devices would decrease the intubation time and improve the glottic view compared to standard DL and with each other. The secondary end points were to determine if there were any significant differences among the three VL devices and DL with respect to adverse clinical outcomes such as need for rescue maneuvers or devices, lowest O_2 saturation during the intubation process, any upper airway morbidity (eg, sore throat, bleeding, postoperative hoarseness [or change in voice]), swallowing difficulties or any dental injuries.

The perioperative data collected consisted of: (1) Demographic information (BMI, age, gender), (2) Airway evaluation (Mallampati class, mouth opening, thyro-mental distance, neck circumference, neck range of motion (Patients were asked to move their neck in extension, flexion, rotation, and lateral binding), presence or absence of teeth) (3) type and amount of drugs administered during induction (4) Times from the passage of the blade between the teeth to obtain glottic view, to placement of the tracheal tube and the appearance of an end-tidal CO2 waveform; (5) Assessment of the glottic view using the Cormack Lehane and POGO scoring systems at the time of tracheal intubation. (6) The number of intubation attempt(s), need to change to a different intubating device, and use of adjuvant airway device (eg, LMA, Bougie). An intubation attempt was defined as the insertion of the laryngoscope blade in to the mouth of the patient, regardless of whether an attempt was made to insert a tracheal tube. (7) Vital signs (in MAP, heart rate, end-tidal CO_2 and SpO_2) were obtained at standardized intervals before, during and after tracheal intubation. (8) A postoperative follow-up assessment was performed approximately 4 hr after surgery by a co-investigator blinded to the intubation device to evaluate the presence and severity of sore throat, any changes in voice, trauma to the lip, tongue, gum, or teeth.

2.1. Sample size determination

Based on the primary and secondary hypotheses, namely the mean time to complete the intubation process and the mean POGO scores, for each of three VL groups compared with the control (DL) group and with each other (i.e., Group 1 vs. Group 2, Group 1 vs. Group 3, Group 1 vs. Group 4, Group 2 vs. Group 3, Group 2 vs. Group 4, and Group 3 vs. Group 4), we used the one-way ANOVA to compare the mean values.

(1) To detect a difference of at least 16 seconds using the Tukey-Kramer (Pairwise) multiple comparison test at a 0.05 significance level with the common standard deviation being 11 [10,16], the total sample of 120 subjects with 30 in each group was required to achieve 85% power.
(2) To detect a difference of at least 20% in the mean POGO scores using the Tukey-Kramer (Pairwise) multiple comparison test at a 0.05 significance level with the common standard deviation being 14% [17], the total sample of 120 subjects with 30 in each group achieves 80% power.

2.2. Statistical analysis

The analysis was performed using SAS 9.3 for Windows (SAS Institute, Cary, NC, USA). Our dataset contained both categorical and continuous measurements. For categorical measures, we presented total numbers (n) with the percentages (%) and used χ^2 test (or Fisher's exact test) to conduct the group comparisons. For continuous measures, we presented mean values with their standard deviations and performed the one-way ANOVA and the Newman-Keuls multiple comparison test among those 4 groups. All tests were 2 sided, and $P \leq .05$ was considered to be statistically significant.

3. Results

The 4 study groups were comparable with respect to demographic characteristics (Table 1). Preoperative vital signs and airway evaluation were similar in all 4 groups (Table 2).The doses of anesthetic drugs and adjuvants administered during induction of anesthesia were comparable in all 4 study groups.

All three VL devices provide similar glottic views at the time of tracheal intubation as assessed using the Cormack Lehane and POGO scores (Table 2). Additionally, all three VL devices improved the glottic view at the time of intubation compared to standard DL ($P < 0.05$). The VLs (Video-Mac, GlideScope and McGrath) all significantly reduced the time required to obtain the glottic view compared to standard DL; however, only the Video-Mac laryngoscope significantly reduced the time required to confirm correct placement (time required to confirm ETCO2) of the tracheal tube compared to the control group and to the GlideScope group (Table 2). The times to successful tracheal intubation did not differ between the Video-Mac and GlideScope groups. The trachea was successfully intubated with two or fewer laryngoscopy attempts in all patients; 93% of the patients in the GlideScope, 93% in the Video-MAC, and 70% in the McGrath groups were intubated on first attempt compared to 74% in the DL group. However, only GlideScope and Video-MAC were significantly different from DL and required less frequent use of Bougie, or change to a different intubation device (Table 2). The incidences of minor postoperative airway complications (eg, sore throat, transient hoarseness, injury to the lip, tongue, and dentition) were comparable among the 4 treatment groups.

Finally, the heart rate response following insertion of the tracheal tube was similar among all 4 study groups; however, there was a significant difference in the post-intubation (peak) HR values compared to the baseline values in all 4 groups. The blood pressure baseline was significantly lower in the GlideScope group compared to the three groups but the response following insertion of the tracheal tube was similar in all groups (Table 3).

4. Discussion

These data is consistent with the findings in earlier studies [8,10] suggesting that use of VL for intubation of obese patients improves the glottic view compared to DL. However, in the current study we also found that the intubation time was significantly shorter in Video-Mac group compared to the DL, GlideScope, and McGrath groups.

Given the availability of several different types of VL devices, it is important to understand the relative advantages and disadvantages of currently marketed VL devices

Table 1 Demographic characteristics, type of surgery, and intraoperative drug dosages of the 4 treatment groups

	(DL (n = 31)	Video-Mac (n = 30)	GlideScope (n = 30)	McGrath (n = 30)
Gender (female/male) (n)	23/8	23/7	23/7	20/10
Age (y)	46 ± 12	44 ± 12	45 ± 12	45 ± 12
BMI (kg/m^2)	42 ± 5	43 ± 8	43 ± 5	41 ± 6
ASA (2/3) (n)	2/29	2/28	0/30	1/29
Race: Asian/black/white/other (n)	0/6/25/0	3/6/21/0	1/5/23/1	0/5/25/0
Types of surgical procedures				
Laparoscopic gastric banding (n)	16	18	12	17
Laparoscopic gastric bypass (n)	3	3	5	2
Roux-en-Y gastric bypass (n)	12	9	13	11
Intraoperative drugs				
Midazolam 1-2 mg (n)	8	6	7	8
Propofol (mg)	216 ± 48	238 ± 65	240 ± 55	242 ± 88
Succinylcholine (mg)	123 ± 34	127 ± 27	146 ± 46	129 ± 44
Succinylcholine (n)	24	24	26	23
Rocuronium (mg)	60 ± 12	60 ± 13	58 ± 12	56 ± 11
Fentanyl 100–150 μg (n)	4	1	1	0
Lidocaine (mg)	73 ± 26	72 ± 25	68 ± 25	72 ± 23
Glycopyrrolate 0.1-0.3 mg (n)	2	3	3	1

Numbers (n), percentages [%], and mean values (± standard deviation).

Table 2 Patient intubation profiles and metric, and Postoperative complications of the 4 treatment groups

	DL (n = 31)	Video-Mac (n = 30)	GlideScope (n = 30)	McGrath (n = 30)
Mouth opening (cm)	5 ± 0.6	5 ± 0.7	5 ± 0.8	5 ± 0.6
Thyro-mental distance (cm)	6 ± 0.6	6 ± 0.6	6 ± 0.8	6 ± 0.7
Neck Circumference (cm)	45 ± 4	44 ± 6	44 ± 4	44 ± 4
Mallampati. classification 1/2/3/4	1/20/10/0	5/17/7/1	5/13/12/0	4/19/7/0
Teeth				
Intact Yes/No (n)	27/4	30/0	28/2	29/1
Gap/missing teeth (n)	3	3	2	0
Denture (n)	1	0	1	0
Ramp 30-40° yes/no (n)	22/9	21/9	19/11	23/7
Cormack Lehane score 1/2/3/4 (n)	12/8/5/6	16/12/2/0 *	18/10/2/0 *	23/7/0/0 *
Percentage of glottic opening (%)	57 ± 41	84 ± 20 *	87 ± 16 *	91 ± 11 *
Need to change intubating device (n) [%]	7 [23]	0 *	0 *	6 [20]
Required rescue with a Bougie (n)	4/6	1/0 *	1/0 *	2/6
Blade stained with blood (n)	1	2	2	4
Intubation attempts 1/ ≥2 (n) [%]	23[74]/8[26]	28[93]/2[7] *	28[93]/2[2] *	21[70]/9[30]
(p = 0.03)	1.3 ± 0.5	1.1 ± 0.4 *	1.1 ± 0.4 *	1.5 ± 1
Times following initial insertion of laryngoscope blade:				
to obtain glottic view (sec)	20 ± 28	9 ± 8 *	12 ± 9 *	10 ± 9 *
to placement of tracheal tube (sec)	43 ± 44	22 ± 15 * † ‡	45 ± 32	40 ± 32
to confirm with CO2 waveform (sec)	70 ± 43	49 ± 25 * †	69 ± 34	62 ± 31
Postoperative complications				
Sore throat (n) [%]	5[16]	6[20]	7[23]	11[36]
Transient change in voice (n) [%]	4[13]	5[16]	1[3]	3[10]
Minor injury to the lip (n) [%]	0	0	0	0
Minor injury to the tongue (n) [%]	0	0	0	0

Numbers (n), percentages [%], and mean values (± standard deviation).

* $P < .05$ compared to Control (DL group).

† $P < .05$ compared to GlideScope.

‡ $P < .05$ compared to McGrath.

compared to standard DL, as well as each other. The Video-Mac was originally developed in 1999 and uses a traditional Macintosh blade with a camera inserted into the handle and external light source cable that can be plugged into various sizes of display screens [9]. The GlideScope was originally developed in 2000 and is another video laryngoscope utilizing a camera at the end of the laryngoscope blade which connects to a separate mountable video screen [11,18].

Table 3 Hemodynamic, oxygen saturation and end-tidal carbon dioxide (CO) values immediately before the blade insertion (Baseline) and 3–5 min after performing tracheal Intubation (Post-intubation) procedure

	DL (n = 31)	Video-Mac (n = 30)	GlideScope) (n = 30)	McGrath (n = 30)
Mean arterial pressure (mmHg)				
Baseline (before induction)	89 ± 12	88 ± 12	85 ± 15 *	89 ± 9
Post-Intubation (peak)	96 ± 21	92 ± 22	99 ± 18	99 ± 18
Heart Rate (bpm)				
Baseline	84 ± 10	87 ± 14	85 ± 17	86 ± 13
Post-intubation (peak)	93 ± 13 †	98 ± 14 †	95 ± 16 †	94 ± 16 †
Oxygen saturation values (%)				
Baseline	99 ± 0.4	99 ± 1.6	99 ± 2.2	99 ± 0.6
Post-intubation (peak)	99 ± 1.6	99 ± 1.9	98 ± 2.4	99 ± 1.3
End-tidal CO_2 (mmHg)				
Post-intubation (peak)	37 ± 5	35 ± 5	36 ± 5	37 ± 5

Values are mean ± SD or numbers.

* $P < .05$ between the 4 groups.

† $P < .05$ compared to baseline.

The McGrath video laryngoscope was developed in 2007 and includes a novel blade with disposable plastic cover, camera and small screen integrated to the handle of the laryngoscope [19].

The same three VL devices we studied were previously compared for tracheal intubation of a morbidly obese surgical population [16]. However that study failed to include a DL control group. The investigators reported that the Video-Mac had a shorter intubation time, less need for adjuncts, fewer intubation attempts, and a better overall satisfaction score compared with the GlideScope and McGrath devices. The current study confirmed these findings. This is important because DL using a Mac laryngoscope blade remains the mostly commonly used technique for performing routine tracheal intubation in the operating room [20–23]. A wide variety of VL devices (e.g., Video-Mac and C-Mac, McGrath, GlideScope, Pentax AWS, King Vision, Airtraq VL) have been developed to facilitate the tracheal intubation because they allow effective retraction of soft tissue, improved visualization of the glottic opening and advancement of the tracheal tube into the airway [24].

Previous studies with various VL devices have reported advantages over DL for elective tracheal intubation in the operating room as well as simulated tracheal intubations in mannequins [25–28]. One study of VL in 100 bariatric patients reported that 98 patients were successfully intubated on the first attempt and the remaining 2 patients were successfully intubated on the second attempt (Kaplan MB, 2006) [9]. Furthermore, Shirgoska and Netkovski [29] suggested that utilization of VL devices can be easily learned and used for managing difficult airway situations in emergency departments and ICUs. Griesdale et al [30], reported that the GlideScope VL is associated with improved glottic visualization in patients with potential or simulated difficult airways compared to DL. While, Andersen et al [31] found that intubation of morbidly obese patients with GlideScope was significant slower than DL, the GS provided a better laryngoscopic view and decreased intubation difficulty scale score.

Maassen and colleagues [18] compared the GS, Video-Mac, and McGrath in morbidly obese patients and found that VL-guided intubation had a high success rate in this population and was performed without excessive force on the maxillary incisors. In addition the Video-Mac had reduced intubation times, required fewer intubation attempts and less frequently required an adjunctive device compared with the GlideScope and McGrath devices. Unfortunately, these authors failed to include a control group involving the 'gold standard', namely DL.

The deficiencies of the current study design were related in part to the fact that this prospective randomized study could not be performed in a blinded fashion; hence the possibly of operator bias exists with respect to intubating conditions and adverse effects on the airway. Secondly, the training and experience of the anesthesiologist participating in this comparative study with 4 different intubating devices is a critical factor in assessing the importance of the reported differences among the 4 techniques. All anesthesiologists participating in this study possessed comparable clinical experience in performing tracheal intubation using the 3 VL devices. Thirdly, the standardized scales used to perform the assessment of the glottis view at the time of tracheal tube placement can be criticized because they are rather subjective. It is important to point out that, the McGrath Series 5 and Video-Mac are being replaced by a McGrath Mac and C-Mac videolaryngoscopy devices, respectively.

5. Conclusion

The use of the Video-Mac, GlideScope and McGrath VL devices for tracheal intubation of obese patients improved the visualization of the larynx. However, only the Video-Mac significantly reduced the intubation time compared to standard DL.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jclinane.2015.12.042.

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