Circulatory responses to nasotracheal intubation: Comparison of GlideScope® videolaryngoscope and Macintosh direct laryngoscope

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Original article

Circulatory responses to nasotracheal intubation: comparison of GlideScope® videolaryngoscope and Macintosh direct laryngoscope

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Keywords: GlideScope® videolaryngoscope; Macintosh direct laryngoscope; nasotracheal intubation; circulatory responses; airway management

Background The GlideScope® videolaryngoscope (GSVL) has been shown to have no special advantage over the Macintosh direct laryngoscope (MDL) in attenuating the circulatory responses to orotracheal intubation, but no study has compared the circulatory responses to nasotracheal intubation (NTI) using the two devices. This prospective randomized clinical study was designed to determine whether there was a clinically relevant difference between the circulatory responses to NTI with the GSVL and the MDL.

Methods Seventy-six adult patients were randomly allocated equally to the GSVL group and the MDL group. After induction of anesthesia, NTI was performed. Non-invasive blood pressure (BP) and heart rate (HR) were recorded before induction (baseline values) and immediately before intubation (post-induction values), at intubation and every minute for a further five minutes. During the observation, times required to reach the maximum values of systolic BP (SBP) and HR, times required for recovery of SBP and HR to postinduction values and incidence of SBP and HR percent changes > 30% of baseline values were also noted. The product of HR and systolic BP, i.e. rate pressure product (RPP), and the areas under SBP and HR vs. time curves (AUCSBP and AUCHR) were calculated.

Results The NTI with the GSVL resulted in significant increases in BP, HR and RPP compared to postinduction values, but these circulatory changes did not exceed baseline values. BPs at all measuring points, AUCSBP, maximum values of BP and incidence of SBP percent increase > 30% of baseline value during the observation did not differ significantly between groups. However, HR and RPP at intubation and their maximum values, AUCHR and incidence of HR percent increase > 30% of baseline value were significantly higher in the MDL group than in the GSVL group. Times required for recovery of SBP and HR to postinduction values were significantly longer in the MDL group than in the GSVL group.

Conclusions The pressor response to NTI with the GSVL and the MDL was similar, but the tachycardiac response to NTI was lesser and of a shorter duration when using a GSVL than when using an MDL.

GlideScope® videolaryngoscope (GSVL) (Saturn Biomedical System Inc., Burnaby, BC, Canada) is a novel intubation system characterized by a video camera with anti-fogging mechanism embedded into a plastic blade. Since the commercial introduction in 2002, numerous studies have indicated that the GSVL can provide comparable or superior laryngeal visualization in the orotracheal intubation compared to the Macintosh direct laryngoscope (MDL), and is an effective device for difficult airway management. However, a previous study showed that the GSVL had no special advantage over the MDL in attenuating the circulatory responses to orotracheal intubation, though it’s specially designed blade with a 60° curvature could decrease the upward lifting force and cervical spine motion required to clearly expose the glottis. Recently, increasing evidence indicates that the GSVL is also an effective device for nasotracheal intubation (NTI) and has been successfully used for NTI in the patients with normal and difficult airways. Except that there are significant differences in the intubation procedure with the GSVL between the oral and nasal routes, NTI can also stimulate the nasal cavity and nasopharynx, which does not occur during orotracheal intubation. Therefore, we speculated that the circulatory responses to NTI with the GSVL are likely to differ from those to orotracheal intubation with the GSVL. However, no study has compared the circulatory responses to NTI using a GSVL and a MDL. This prospective randomized clinical study was designed to determine whether there was a clinically relevant difference between the circulatory responses during NTI with the GSVL and the MDL.
responses to NTI with the GSVL and the MDL in healthy anesthetized adult patients.

METHODS

Subjects selection and grouping
Following institutional ethics committee approval and written informed consent, 76 adult patients, ASA physical status 1, scheduled for elective plastic surgery requiring general anesthesia with the NTI were included in this study. Exclusion criteria were a history of reactive airway disease, a predicted difficult airway, gastroesophageal reflux, morbid obesity, diabetes mellitus, hypertension and cardiovascular diseases and the use of medications known to affect blood pressure (BP) and heart rate (HR). Patients were randomly allocated to the GSVL group and the MDL group. Randomization was performed using computer generated random numbers, enclosed in sealed envelopes. Before each patient entered the operating room, a sealed envelope was randomly opened and the patient was assigned to the indicated group.

Anesthetic managements and tracheal intubation
All patients fasted overnight and were restricted from oral intake of clear fluid for 4 hours. They were premedicated with midazolam 0.1 mg/kg (maximum 5 mg) and scopolamine 0.01 mg/kg (maximum 0.3 mg) injected intramuscularly 1 hour before induction. Thirty minutes prior to arriving in the operating room, each patient’s nasal cavities were pretreated with two sprays of xylometazoline during inspiration. A relatively clear nasal passage was selected for NTI. After patients entered the operating room, non-invasive BP, a three-lead electrocardiogram and pulse oxygen saturation (SpO₂) were monitored with a multifunction monitor (Datex.Ohmeda F-CU8, Datex Instrumentarium, Helsinki, Finland). Baseline values of BP and HR were recorded after a stabilization period of 10 minutes. Then a 20 gauge intravenous (IV) cannula was inserted and an infusion of lactated Ringer’s solution was established. The Portex preformed, cuffed RAETM nasal tubes (Portex Limited Hythe, Kent, England) were used for all intubations, size 6.5 mm for females and size 7 mm for males.10 The nasal tube was adequately lubricated with 2% lidocaine gel (Beijing Zizhu Pharmaceutical Co., Ltd, Beijing, China, Batch No:070105). Before induction, the work mode of the multifunction monitor for measurement of BP was changed to the continuous mode with a response time of about 20 to 30 seconds.

When any response to verbal command was lost, patients were ventilated via a facemask with 100% oxygen. If any difficulty was encountered in performing facemask ventilation after induction, the patient was withdrawn from the study and his/her card was resealed in an envelope and randomly placed among the remaining envelopes to be used later. NTI was started 3 minutes after propofol injection. All intubation procedures were performed by an experienced anesthetists who had worked in clinical anesthesia for at least 10 years and performed the NTI using the GSVL and the MDL in more than 100 patients before the start of this study.

After induction the patient was placed in the supine position and patient’s head and neck were placed in the sniffing position. A nasal tube was inserted via the preselcted nostril until its tip passed through the posterior naris (usually at the 15- to 16-cm mark).10,11 In the GSVL group, the GSVL blade was introduced into the patient’s mouth along the midline, gliding downwards on the surface of tongue following the anatomical curvature of the oral cavity and pharynx while the base of the tongue, palate, uvula and epiglottis were visualized sequentially on the high resolution LCD monitor.1 The tip of the GSVL blade was placed into the epiglottic vallecula and gently lifted to expose the glottis. External laryngeal compression was routinely applied to improve the laryngoscopic view. After the larynx was clearly exposed, the nasal tube’s tip was aligned with the glottis and inserted into the trachea under direct vision on the monitor. The nasal tube was advanced downwards until the cuff was 2 cm below the vocal cords. If the nasal tube’s tip failed to be aligned with the glottis, the nasal tube was withdrawn slightly and the following auxiliary measures were then taken: left or right rotation of the nasal tube at the external naris, external laryngeal manipulation and adjustment of the patient’s head-neck position.10,11 In the MDL group, laryngoscopy and NTI were performed using the Macintosh laryngoscope with a size 3 blade (Timesco, England) according to the conventional manner with the aid of Magill forceps if necessary. The difficulties encountered and the maneuvers adopted during laryngoscopy and intubation, and the intubation time, namely the period from termination of manual ventilation using a facemask to restarting of ventilation through a nasal tube, were recorded.11 If SpO₂ decreased to 95% or less due to the prolonged intubation time, manipulation was stopped and the facemask ventilation with 100% oxygen was applied. Then the intubation was again attempted. Patients who required more than one attempt to achieve successful intubation were excluded from statistical analysis of the data.

After the successful intubation, the nasal tube was connected to the anesthesia breathing system for intermittent positive pressure ventilation. Anesthesia was maintained with 1% isoflurane and 60% nitrous oxide in oxygen. The surgical field was exposed under direct vision and the surgery was started.
Variables measured
BP and IIR were recorded immediately before intubation of (post-induction values), at intubation and every minute for a further 5 min. The maximum and minimum values of BP and HR during the observation were obtained from the record tracing of the multifunction monitors. The product of HR and systolic BP (SBP) or rate-pressure product (RPP) at all the measuring points were calculated. Times required to reach the maximum values of SBP and HR, namely the periods from initiation of intubation to occurrence of their maximum values, and times required for recovery of SBP and HR to postinduction values, namely the periods from completion of intubation to recovery of SBP and HR to within 10% of postinduction values, were observed using a stopwatch. If SBP and HR did not recover to within 10% of postinduction values by 5 minutes following intubation, they were observed until the target values were reached. The watch was stopped when SBP and HR recovered to postinduction values. The incidences of SBP and HR percent changes >30% of baseline values were recorded. During the observation, no manipulation, including movement of head and tube fixation, nor skin preparation of the operating field was performed.

In this study, a IIR of < 50 beats/min was defined as bradycardia. If bradycardia occurred, atropine 5–10 µg/kg was injected IV for treatment and the patient was excluded from statistical analysis of the data. Also, arrhythmia, if present and lasted for > 10 seconds, was noted. An arrhythmia was defined as any ventricular or supraventricular premature beat or any rhythm other than sinus.

Statistical analysis
All data were analyzed using SPSS (Version 10.1, SPSS Inc., Chicago, IL) and POMS (Version 5.0, Shanghai Scientific and Technical Publishers, Shanghai, China) statistical software. The areas under SBP and HR vs time curves (AUCSBP and AUCHR) were calculated with all the measuring points as the X-axis and values of SBP and HR at all the measuring points as the Y-axis. The comparisons of non-parametric data between groups were done using a chi-square test. The comparisons of parametric data between groups were made using the two tailed Student’s t test. The intragroup differences of the circulatory variables recorded over time were analyzed using the Friedman’s repeated-measures analysis of variance. The hypothesis of this study was that there would be a clinically significant difference between the circulatory responses to NTI with the GSVL and the MDL. The difference in HR and SBP percent increase >30% of baseline in the observation, 35 patients in each group would be required when α = 0.05 and β = 0.2.14,16 Allowing for possible exclusions, we chose to examine a minimum of 38 patients each group. The quantitative data were expressed as mean ± standard deviation (SD). P <0.05 was considered statistically significant.

RESULTS

Patients’ demographic data and quality of tracheal intubation
A total of 76 patients were included in this study. No patient was excluded from statistical analysis of the data due to difficult facemask ventilation and repeated intubation attempts. The two groups were comparable with respect to demographic data (P >0.05) (Table 1). The intubation times were (56±15) seconds in the GSVL group and (62±15) seconds in the MDL group, with no significant difference between groups (P >0.05). To align the nasal tube’s tip with the glottis, Magill forceps and auxiliary maneuvers were required in 0 and 5 patients respectively, in the GSVL group, 7 and 16 patients in the MDL group. The uses of Magill forceps and auxiliary maneuvers were less frequent in the GSVL group than in the MDL group (P <0.005). The resistance to downward advancement of the nasal tube into the trachea after its tip passed the glottis occurred in 7 patients in the MDL group and 1 case in the GSVL group (18% vs 3%, P <0.05).

| Table 1. Demographic data (mean±SD except for gender data) |
|-----------------|-------------|-------------|
| Items | GSVL group (n=38) | MDL group (n=38) |
| Gender (M/F) | 3/35 | 4/34 |
| Age (y) | 27.5±6.6 | 26.1±6.6 |
| Height (cm) | 163.1±6.3 | 164.0±5.4 |
| Weight (kg) | 51.4±8.0 | 54.3±6.3 |
| Body mass index (kg/m²) | 19.2±2.2 | 20.1±2.1 |

GSVL: GlideScope® videolaryngoscope; MDL: Macintosh direct laryngoscopy. There were no statistically significant differences in demographic data between groups.

Circulatory responses to nasotracheal intubation
The baseline values of all circulatory variables did not differ significantly between groups (P >0.05). Following induction of anesthesia in both groups, BP and RPP decreased significantly from baseline values, but HR remained stable. In the MDL group, BP, HR and RPP at intubation were significantly higher than postinduction values, and HR at intubation and maximum values of BP, HR and RPP during the observation also exceeded baseline values. In the GSVL group, only BP and RPP at intubation were significantly higher than postinduction values (Figures 1–3).

BPs at all the measuring points, AUCSBP, maximum values of BP, incidence of SBP increase > 30% of baseline value and incidences of SBP and HR decreases > 30% of baseline values during the observation did not differ significantly between groups. However, HR and
Figure 1. Systolic blood pressure changes associated with the nasotracheal intubation in the two groups. Points represent mean ± SD, n=38 in each group. *P <0.05 compared with baseline values; †P <0.05 compared with postinduction values. There were no statistically significant differences in systolic blood pressures at any observed points between groups.

Figure 2. Heart rate changes associated with the nasotracheal intubation in the two groups. Points represent mean ± SD, n=38 in each group. *P <0.05 compared with baseline values; †P <0.05 compared with postinduction values; ‡P <0.05 compared with the GSVL group.

RPP at intubation and their maximum values, AUC_{HR} and incidence of HR percent increase > 30% of baseline value were significantly higher in the MDL group than in the GSVL group (Figures 1-4).

Times required to reach maximum values of SBP and HR during the observations were not significantly different between groups. However, times required for recovery of SBP and HR postintubation were significantly longer in the MDL group than in the GSVL group (P <0.05) (Table 2).

Premature atrial contraction associated with laryngoscopy and intubation were observed only in two patients in the MDL group and resolved spontaneously within 2 minutes without specific therapeutic intervention. No patient required treatment for bradycardia and SpO_{2} in all patients was maintained at 100% throughout the observation.

**DISCUSSION**

The primary goal of this investigation was to determine...
Table 2. Areas under SBP and HR vs time curves

<table>
<thead>
<tr>
<th>Items</th>
<th>GSVL group (n=38)</th>
<th>MDL group (n=38)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUCBP</td>
<td>851±98</td>
<td>874±77</td>
</tr>
<tr>
<td>AUCIR</td>
<td>661±74</td>
<td>720±102*</td>
</tr>
<tr>
<td>Times to MAX_{SBP} (s)</td>
<td>82±18</td>
<td>79±20</td>
</tr>
<tr>
<td>Times to MAX_{HR} (s)</td>
<td>65±14</td>
<td>61±16</td>
</tr>
<tr>
<td>Recovery times_{SBP} (s)</td>
<td>137±22</td>
<td>186±22*</td>
</tr>
<tr>
<td>Recovery times_{HR} (s)</td>
<td>65±11</td>
<td>177±28*</td>
</tr>
</tbody>
</table>

*(AUCBP w/ HR, times required to reach maximum values of SBP and HR during the observation (Times to MAX_{SBP} or HR), and times required for recovery of SBP and HR to postinduction values after intubation (Recovery times_{SBP} or HR)) in the two groups. \(^{7}\)P<0.05 compared with the GSVL group.*

whether there was a clinically relevant difference between the circulatory responses to NTI with the GSVL and the MDL. Using strict exclusion criteria, we controlled for factors known to interfere with BP and HR changes during laryngoscopy and intubation. There were no significant differences between groups in the distribution of gender, age, height, weight and BMI. BP and HR were measured using the same monitors in both groups. The comparable anesthetic equipment was also used in all cases. The drugs used in this study are produced in a single factory and have the same batch number. To minimize bias, all intubations were performed by the anesthetists experienced in the two manipulations. The intubation time did not differ between groups. Because the depth of anesthesia at the time of intubation can influence the cardiovascular intubation response,\(^{14,15}\) we also standardized the induction technique in this study. Therefore, we have reason to believe that comparisons of circulatory variables between groups are valid.

The result of this study clearly showed that the NTI using a GSVL caused a lesser and shorter tachycardic response compared with that using a MDL. Additionally, RPP at intubation and its maximum value during the observation were significantly lower in the GSVL group than in the MDL group. These results suggest that the GSVL provides the some benefits in attenuating the circulatory responses to NTI.

The two main causes of the circulatory responses to intubation are the stimuli to the oropharyngeal structures produced by laryngoscopy and the stimuli to the larynx and trachea exerted by tracheal tube insertion.\(^{17,18}\) According to the available data, we consider that the reasons for our results may be multifactorial. First, the special blade design of the GSVL can provide a clear laryngeal view without alignment of the oral, pharyngeal and laryngeal axes.\(^8\) Therefore, the upward lifting force and compression and distortion of the oropharyngolaryngeal structures required to expose the glottis can be significantly reduced. These factors help to decrease stimuli to the oropharyngolaryngeal structures during laryngoscopy. It is suggested by the manufacturer that this sort of force is approximately 4.9 to 13.7 N when using a GSVL.\(^8\) In contrast, maximum force transmitted by a direct laryngoscope blade onto the base of the tongue is reported to be as high as 35 to 47.6 N during a complete laryngoscopy.\(^{18}\) Therefore, it is reasonable to assume that the GSVL reduces maximal force transmitted to the larynx and trachea, resulting in a lower sympathetic response.\(^{19}\) Second, because the laryngeal exposure using a GSVL does not depend on a line of sight, the height of the larynx evaluated anteriorly is possibly decreased. Moreover, introducing the GSVL blade into the mouth along the midline can also minimize the displacement of oropharyngolaryngeal tissues from the midline.\(^1\) Therefore, the nasal tube’s tip passing through the choana will be more aligned with the laryngeal aperture.\(^11\) In contrast, the laryngeal exposure using the MDL depends upon alignment of the oral, pharyngeal, and laryngeal axes. It needs to compress and distort the oropharyngolaryngeal structures, and possibly to elevate the larynx more anteriorly. All these can not only cause the displacement of the oropharyngolaryngeal tissues from the midline, but also increase the angle between the nasal tube’s tip passing through the choana and the laryngeal aperture. This can result in difficulty in the alignment of the nasal tube’s tip with the glottis. To overcome this difficult, use of a Magill forceps and auxiliary maneuvers are often required. These manipulations may obviously impose stimuli in the oropharyngolaryngeal structures. In our study, the uses of both Magill forceps and auxiliary maneuvers were less frequent in the GSVL group than in the MDL group. This further supported the view that the GSVL is an effective device for NTI.\(^11\)

Third, when NTI is performed using a GSVL, a lesser angle between the nasal tube’s tip and the laryngeal aperture can also make the axis of the nasal tube more parallel to that of the trachea, thereby advancing the nasal tube downwards into the trachea easier.\(^21\) This may decrease friction and stimuli to the larynx and trachea. However, when NTI is performed using MDL, a larger angle between the nasal tube’s tip and the laryngeal aperture is able to cause downward advancement of the nasal tube into the trachea more difficult because the nasal tube’s tip will always have a tendency to advance anteriorly, and thus become stuck on a cartilaginous ring on the anterior tracheal wall.\(^22\) When such a problem is encountered, some auxiliary maneuvers are often required to be taken for relief of the obstruction. It is without doubt that these maneuvers can increase the stimuli to the larynx and trachea.\(^23\) Shribman and colleagues\(^24\) hypothesized that laryngoscopy produced balanced stimulation of vagal and cardiac accelerator fibers, whereas the tracheal tube insertion produced less vagal stimulation. This might be the main reason why the tachycardic response to NTI was stronger and of longer duration in the MDL group than in the GSVL group.

This investigation also demonstrated that in the GSVL group, maximum increases of both BP and HR during the observation did not significantly exceed baseline values. These results suggested that the depth of anesthesia in our study could effectively suppress the circulatory responses to NTI using a GSVL. However, in the MDL group, maximum increases of both BP and HR were evident during the observation.\(^10\)
maximum increases of both BP and HR significantly exceeded baseline values. Additionally, incidence of HR percent increase > 30% of baseline values during the observation was up to 24% in the MDL group. These data indicated that the depth of anesthesia in our study could not satisfactorily inhibit the circulatory responses to NTI using a MDL. These modest circulatory responses to NTI using a MDL appear unlikely to result in deleterious effects in healthy patients, but they may be potentially harmful, and avoidance of such circulatory changes during NTI is crucial in the presence of cardiovascular diseases, hypertension, cerebrovascular malformation or increased intracranial pressure. Therefore, we consider that these circulatory responses to NTI using a MDL should be considered as complications of this common airway manipulation.

RPP is an index of myocardial oxygen consumption, and a value exceeding 22 000 is commonly associated with myocardial ischemia. Maximum increases of RPP during observation were 10% and 21% of baseline value in the GSVL and MDL groups, respectively, but no patient had a RPP of >15 000. These results mean that the circulatory responses to NTI using a GSvl and a MDL is not associated myocardial ischemia due to increased oxygen consumption in anesthetized healthy adult patients.

There were the several aspects of our study design that deserve special attention. First, patients with cardiovascular diseases and hypertension were excluded because they are at risk of a catastrophe (myocardial insufficiency, cardiac dysrhythmia, stroke, etc.) and may require more protection from the stressful influences of laryngoscopy and intubation. Therefore, one should extrapolate our results to patients with cardiovascular diseases and hypertension cautiously. Second, we also excluded the patients with a predicted difficult airway. Our data only reflects the circulatory changes associated with the NTI using a GSvl and a MDL in patients with a normal airway. Previous studies have demonstrated that tracheal intubation is more difficult and required more airway manipulation in patients with a predicted difficult airway than in those with a normal airway. It is no doubt that the tracheal intubation can result in the stronger stimuli to the airway and more severe circulatory responses in patients with a predicted difficult airway compared with those with a normal airway. Therefore, extrapolating our results to the patients with a predicted difficult airway can not provide reliable information. Third, we selected a indirect non-invasive measurement technique of BP because it makes determinations easy and practical in the clinical setting. Although this technique has been shown to be reasonably accurate and has been widely used in the assessment of the pressor response to intubation, it provides only intermittent reports and typically takes 20–30 seconds to make a determination. In this investigation, the limitations of inability to record BP missed and that the true peak pressure could be higher than that observed. Direct intra-arterial pressure measurement would have been more precise and continuous, but the use of this technique would not be ethically justifiable because of its potential side-effects should not occur in this type of surgery and relatively healthy patients that we studied. Fourth, in this work, we studied only anesthetized patients, in whom circulatory responses to NTI might have been partially attenuated by the anesthetic agents used (particularly fentanyl, propofol and isoflurane). Therefore, anesthetists should be aware that this study does not exclude the possibility that the circulatory response may be exaggerated, and thus potentially harmful, in other situations where NTI is performed using a GSvl or a MDL, for example in lightly anesthetized patients or awake patients. These problems deserve further study.

In conclusion, our study has demonstrated that the NTI using a GSvl can result in a lesser and shorter tachycardiac response than that using an MDL, and the GSvl can provide some benefits in attenuating the circulatory responses to NTI.

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