Endotracheal intubation using videolaryngoscopy causes less cardiovascular response compared to classic direct laryngoscopy, in cardiac patients according a standard hospital protocol


Abstract: Introduction: Previous studies comparing Glidescope and classic direct laryngoscopy did not show an attenuation of CV responses to endotracheal intubation. In the present study, we hypothesize that indirect videolaryngoscopy can attenuate cardiovascular responses to endotracheal intubation.

Methods: In a randomized cross-over study, eighty adults (ASA PS II-III) were included. Both direct and indirect videolaryngoscopies were used in a random order, in the same patient. Cardiovascular responses to intubation were recorded as a relative change in rate pressure product (RPP = systolic blood pressure times heart rate) from baseline values. A linear mixed model was used to study the association between the outcome variable RPP and the type of laryngoscope used.

Results: The relative increase of the RPP at intubation was significantly smaller (i.e. 27%, P < 0.001) using videolaryngoscopy compared to the classic direct laryngoscopy. Cardiovascular responses were blunted by an additional 10.2% (P = 0.029), when the patient was on beta-blockade.

Conclusions: Our study shows less hemodynamic responses during endotracheal intubation using indirect videolaryngoscopy compared to classic direct laryngoscopy.

Key words: Cardiovascular responses, videolaryngoscopy, classic laryngoscopy.

Introduction

Cardiovascular responses to endotracheal intubation have been well documented for direct laryngoscopy and are caused by the noxious stimuli to the oropharyngeal structures (laryngoscopy) and the larynx and trachea (exerted by the tracheal tube insertion) (1). Previous studies showed diminished cardiovascular responses to endotracheal intubation after beta blocker therapy (2). The improved glottic view provided by indirect videolaryngoscopy reduces the need for excessive force on the laryngoscope (3).

A comparison of the cardiovascular responses to endotracheal intubation using both indirect videolaryngoscopy and direct laryngoscopy within the same patient has not yet been described.

The primary goal of this randomized cross-over study is to determine whether there is a difference between cardiovascular responses to endotracheal intubation using direct laryngoscopy compared to indirect videolaryngoscopy. Secondly, we tested cardiovascular responses in patients with and without beta-blocker therapy.

Ralph L. J. G. Maassen, Anaesthesiologist, M.D.; Barbe M. A. Pieters, Resident in Anaesthesiology, M.D.; Brando Maathuis, Bachelor of Science; Jan Serroyen, Assistant Professor, Ph.D.; Marco A. E. Marcus, Professor of Anaesthesiology, M.D., Ph.D.; Patrick Wouters, Professor of Anaesthesiology, M.D., Ph.D.; André A. J. Van Zundert, Professor of Anaesthesiology, M.D., Ph.D., F.R.C.A., E.D.R.A., F.A.N.Z.C.A.

(*) Departments of Anaesthesiology Catharina Hospital, Eindhoven, Netherlands & University Hospital Maastricht, the Netherlands.

(***) Department of Biomechanical Engineering, Mechanical, Materials and Maritime Engineering, Delft University of Technology, Delft, the Netherlands.

(**) Department of Methodology and Statistics. CAPHRI. Maastricht University, the Netherlands.

(******) Department of Anaesthesiology University Hospital Maastricht, the Netherlands.

(******) Department of Anesthesiology, Ghent University Hospital, Ghent, Belgium.

Corresponding author: Prof. Dr. André van Zundert, Department of Anaesthesiology, Intensive Care and Pain Therapy, Catharina Hospital – Brabant Medical School, Michelangeloalaan 2, NL-5623 EJ Eindhoven, The Netherlands. Tel.: +31 40 2399111. Fax: +31 40 2463978. E-mail: zundert@iae.nl

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Monitoring

After arrival of the patient in the operating theatre, standard monitoring was attached using a pulse oximeter, a five-lead ECG and bispectral index monitoring (BIS), using a multifunction monitor (Datex Ohmeda F-CU 8; Datex instrumentarium Helsinki, Finland).

ST segment analysis (leads II and V) was performed, using standard criteria for myocardial ischemia (5). Well before induction of anesthesia the patient received a standard 18 gauge intravenous cannula and an intra-arterial cannula. A stabilisation period of three minutes was allowed to acquire patient’s actual blood pressure values.

Laryngoscopy

All patients underwent endotracheal intubation using both the classic (direct) laryngoscope and the indirect videolaryngoscope in a random order, separated by a washout period of three minutes.

Intra-procedural metrics

During intubation, intra-procedural metrics of intubation difficulty (Cormack-Lehane grade) were measured, as well as our dependent parameters of effective airway time, number of attempts, and use of extra adjuncts to facilitate intubation. The need for extra maneuvers to optimize the visualization of the glottis entrance (e.g. backward upward rightward pressure (BURP)) was also recorded. The number of intubation attempts was counted as each approach of the endotracheal tube (ETT) to the glottis entrance. If after two attempts the patient still could not be intubated, a stylet or gum elastic bougie was used to facilitate intubation.

Effective airway time, using a stopwatch, was measured (by an assistant) as the time between picking up the ETT (Hi-contour™, Mallincrodt Medical, Athlone, Ireland) and the visual passage of the tube until the vocal cords were between the two black line markings on the distal end of the ETT. Interim bag and mask time, if needed, was not included in the effective airway time. Patients requiring an effective airway time of more than two minutes, were excluded from statistical analysis of data.

Anesthesia & hemodynamic measurements

Following a three minutes stabilization period, with the patient positioned horizontally, systolic
Blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP) and heart rate (HR) were obtained. Patients were randomly allocated to receive first either direct Macintosh laryngoscopy or indirect videolaryngoscopy (VLS), using the C-Mac™ Storz® (Karl Storz, Tuttlingen, Germany) by selecting a sealed card.

Anesthesia was induced, after routine preoxygenation, with fentanyl 5 µg/kg i.v., followed by etomidate 0.3 mg/kg and rocuronium 1 mg/kg based on lean body mass, followed by 2% sevoflurane in oxygen. Three minutes after administering rocuronium, adequate neuromuscular relaxation was tested using train of four (TOF)-monitoring.

Subsequently, the ETT was inserted, using both direct laryngoscopy and indirect videolaryngoscopy in a random order. Measurements were taken during the first endotracheal intubation, without inflating the cuff of the ETT. Subsequently, the ETT was withdrawn and the patient was mask ventilated with sevoflurane 2% for a stabilization (washout) period of three minutes. The follow-up measurements were taken at one and three minutes after withdrawal of the ETT and new baseline values were obtained. Then, the second endotracheal intubation was carried out, including inflation of the cuff of the ETT. Again hemodynamic measurements were obtained at intubation (before inflation of the cuff) and at one and three minutes after endotracheal intubation.

The bispectral index (BIS) values were kept between 40 and 50 (on average 45), to standardize the depth of anesthesia and 2% sevoflurane in oxygen was added if needed.

Cardiovascular responses to intubation were calculated as a relative change in rate pressure product (RPP = systolic blood pressure times heart rate) from baseline values.

Anesthesia was maintained with sevoflurane 2% in oxygen. The ventilator settings were adjusted to maintain the end tidal CO₂ level between 4.5 kPa and 5.2 kPa.

Postoperative care was given at the postoperative anesthesia care unit (PACU). Within two weeks after surgery, an independent operator interviewed all patients using a standard questionnaire. We assessed whether, and to which extent, the patients complained of a sore throat postoperatively.

Statistics

A linear mixed model was used to study the association between the outcome variable RPP and the type of laryngoscope used. The linear mixed model enabled us to extend the classical cross-over analysis and allowed us to correct for additional covariates (i.e., beta blocker administration and effective airway time). P-values less than 0.05 were considered as statistically significant.

To achieve a significance level (alpha) of 0.05, a power of 95%, a standard error of 8% and a response difference in RPP from 15 to 20% between both devices, we calculated a sample size of 72 patients. The calculated standard error was based on a pilot study of 20 patients. We included 80 patients.

All statistical analyses were performed using SAS® (SAS Institute Inc. Cary, NC, USA) version 9.2.

Results

A total of 80 patients, of whom 48 were on beta-blocker therapy, were included in this study, and all were successfully intubated using both indirect videolaryngoscopy and direct classic laryngoscopy, without adverse events. No patients were excluded from analysis because of prolonged effective airway time.

Patient characteristics and pre-procedural intubation conditions did not differ substantially between patients (Table 1). Peripheral oxygen saturation was maintained above 95% in all patients throughout the laryngoscopy and intubation period. We did not detect any injury of the palatoglossal arch or dental injury in any of the patients. Only three patients, who had an effective airway time of more than 50 seconds, reported postoperatively minor, self-limiting sore throat complaints, which did not require any treatment. No signs of myocardial ischemia were seen on the ECG during induction or recovery. The effective airway time was significantly longer when using classic laryngoscopy (10.3 ± 13.8 s) compared to videolaryngoscopy (6.1 ± 5.9 s, P = 0.002). There was no significant correlation between effective airway time and RPP after correction for laryngoscope type and beta blocker effect.

The relative increase of the RPP at intubation was significantly smaller (i.e. 27%, P < 0.001) using videolaryngoscopy compared to the classic direct laryngoscopy.

Cardiovascular responses were blunted by an additional 10.2% (P = 0.029), when the patient was on beta blockade (Fig. 1).

Based on mean RPP values (Table 2), maximal values of RPP during observation increased by 48.3% and 189% of their baseline values during indirect videolaryngoscopy and direct classic
indirect (Macintosh) videolaryngoscopy, compared to direct (classic) laryngoscopy (CL) for both patients with (Beta) and without beta blockade (No beta).

Table 2 shows the mean RPP values for the different measurement occasions within the different groups (i.e. classic laryngoscopy and VLS with and without beta blockade).

**Table 1**  
Patient characteristics, pre- and intraprocedural intubation conditions

<table>
<thead>
<tr>
<th></th>
<th>Incidence n = 80</th>
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<tbody>
<tr>
<td>Male: female, n (%)</td>
<td>55:25 (69:31)</td>
</tr>
<tr>
<td>Age, yrs</td>
<td>66.2 ± 10.2</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>80.9 ± 15.5</td>
</tr>
<tr>
<td>Height, cm</td>
<td>172 ± 9</td>
</tr>
<tr>
<td>ASA physical status; I:II:III:IV, n (%)</td>
<td>0:67:13:0 (0:84:16:0)</td>
</tr>
<tr>
<td>Body mass index, kg.m²</td>
<td>27.0 ± 4</td>
</tr>
<tr>
<td>Thyromental distance, mm</td>
<td>77.8 ± 8</td>
</tr>
<tr>
<td>Mallampati grade; I:II:III:IV, n (%)</td>
<td>34:41:5:0 (43:51:6:0)</td>
</tr>
<tr>
<td>Dentition; full dentures:single:none, n (%)</td>
<td>32:6:42 (40:7:5:52.5)</td>
</tr>
</tbody>
</table>

Data are reported as n (%), or mean ± SD.

Discussion

This study clearly demonstrated less cardiovascular responses to endotracheal intubation using indirect (Macintosh) videolaryngoscopy, compared to direct (classic) laryngoscopy.

Direct laryngoscopy and endotracheal intubation affect the cardiovascular system and lead to an average increase in blood pressure by 40-50% and 20% increase in heart rate (6). It has been demonstrated that cardiovascular responses can be attenuated by beta-blockers (2). Studies (7, 8) that investigated cardiovascular responses to endotracheal intubation, comparing direct laryngoscopy and
indirect videolaryngoscopy with the use of the Glidescope®, were not able to show an attenuation of the cardiovascular responses when videolaryngoscopy was used. The Glidescope® videolaryngoscope offers an excellent view of the glottis, but intubation is not always straightforward. The use of a stylet with a relatively pronounced curve (the best angle is reported to be 90°) (9, 10) at the distal end is the most helpful and needed in the majority of the cases in order to advance the tip of the ETT to the glottic opening (11). Stylet use goes hand in hand with more manipulations and increases the potential noxious stimulation to the trachea, which can provoke cardiovascular responses.

Previous studies (11, 12) demonstrated that clinical differences do exist between different brands of videolaryngoscopes and found that a Macintosh blade results in better intubation scores and less need for a styletted ETT than videolaryngoscopes which use other than Macintosh blades. In our study we therefore used the Storz® C-MAC videolaryngoscope which incorporates a Macintosh blade.

By testing the cardiovascular response curve for both devices – in a random order – within the same patient (cross-over design), we were able to register and compare hemodynamic responses within the same experimental environment and minimized confounding factors (e.g. medication use) which itself could influence the cardiovascular response curve.

RPP (= systolic blood pressure times heart rate) is an index of myocardial oxygen consumption (13). A RPP of 22,000 is commonly associated with myocardial ischemia (14). Our results showed that although the maximal values of RPP during observation increased by 48.3% and 189% of their baseline values during indirect videolaryngoscopy and direct classic laryngoscopy, respectively, they never exceeded 22,000 in our study.

Takahashi and colleagues concluded that hemodynamic changes following endotracheal intubation are likely to occur because of direct tracheal irritation rather than stimulation of the larynx (15). In our study both indirect videolaryngoscopy and direct laryngoscopy were performed in a random order, followed by endotracheal intubation. We showed less cardiovascular responses to endotracheal intubation using indirect videolaryngoscopy, compared to direct (classic) laryngoscopy. This implicates that laryngeal stimulation might play a greater role in cardiovascular responses to endotracheal intubation than suggested in the literature.

This study has several limitations:

1) the attending anaesthesiologist was not blinded to the type of laryngoscope used, although the order of use (indirect videolaryngoscopy or direct laryngoscopy) was randomized;
2) the observer recording time to intubation and the RPP were not blinded;
3) beta-blocked and non-beta-blocked patients in the conventional laryngoscopy group did not re-achieve their pre-intubation baseline values, while those in the videolaryngoscope group did (Fig. 1). This could potentially affect the results of the group having undergone direct laryngoscopy first (n = 42). This group may have been limited as to the maximal RPP obtainable if they started the second period at a higher HR/SBP than those who underwent videolaryngoscopy first (n = 38);
4) the protocol (e.g. drugs and doses) applied, is our own protocol in cardiac anaesthesia, which may be different in other institutions;
5) this study restricts itself by using only one type videolaryngoscope, and therefore cannot give any conclusion about the results in other VLS. More studies with other videolaryngoscopes are needed to confirm whether a Macintosh blade shows superiority over other blades.

Evidence suggests that the Macintosh VLS has several advantages above direct classic laryngoscopy (3, 11, 12). Additionally, this study clearly

<table>
<thead>
<tr>
<th>Measurement Occasion</th>
<th>No Beta CL</th>
<th>Beta CL</th>
<th>No Beta VLS</th>
<th>Beta VLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>7638 ± 1873</td>
<td>6663 ± 1632</td>
<td>7777 ± 1852</td>
<td>7284 ± 1883</td>
</tr>
<tr>
<td>Intubation</td>
<td>11022 ± 3400</td>
<td>8529 ± 3078</td>
<td>8953 ± 2782</td>
<td>7834 ± 2236</td>
</tr>
<tr>
<td>Intubation + 1 min</td>
<td>9869 ± 2853</td>
<td>7939 ± 2569</td>
<td>8901 ± 3038</td>
<td>7725 ± 2668</td>
</tr>
<tr>
<td>Intubation + 3 min</td>
<td>8220 ± 1863</td>
<td>7246 ± 2052</td>
<td>7992 ± 2254</td>
<td>6847 ± 2181</td>
</tr>
</tbody>
</table>

Mean RPP values (± SD) for the different measurement occasions within the different groups (i.e. classic laryngoscope and videolaryngoscope with and without beta blockade).
demonstrates less cardiovascular responses to endotracheal intubation when using Macintosh videolaryngoscopy (even in patients on beta-blockade).

Although it has been shown recently that cardiovascular responses to laryngoscopy and tracheal intubation – in patients with and without beta-blockade - were not associated with cardiac ischaemia (as assessed by ST-segment monitoring) (16), specific conditions (e.g. intracranial hypertension, cerebral aneurysms, large aortic aneurysms, cardiac ischemia or recent myocardial infarction) benefit from anaesthetic management diminishing the cardiovascular responses to laryngoscopy and intubation (17). Macintosh videolaryngoscopy seems to be contributory to achieve this.

CONCLUSION

Our study provides evidence of less hemodynamic responses during endotracheal intubation using indirect videolaryngoscopy incorporating a Macintosh blade compared to classic direct laryngoscopy.

Even if the patient is on beta-blocker therapy, diminished cardiovascular responses at intubation are recorded after indirect laryngoscopy compared to direct laryngoscopy.

References