# Hemodynamic Responses To Endotracheal Intubation Comparing The Airway Scope®, Glidescope®, And Macintosh Laryngoscopes

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**Citation**

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**Abstract**

Background Hemodynamic responses to laryngoscopy and tracheal intubation are concerning, as adverse cardiovascular events may result. Two novel video laryngoscopes that may attenuate this stress response in comparison to direct laryngoscopy with the standard Macintosh (MAC) blade are the Airway Scope® (AWS) and the Glidescope® (GS). We performed a randomized prospective study to investigate this hypothesis.Methods 60 normotensive adult ASA I or II patients were enrolled, and randomized to intubation using either AWS (n=20), GS (n=20), or MAC (n=20). A standard induction was performed. All intubations were performed by a single anesthesiologist. Hemodynamic values were recorded at baseline, after induction, at intubation, and at every minute for five minutes after intubation.Results Intubation time was highly significantly longer in the AWS group and GS group compared to the MAC group (P <0.01, P < 0.01, respectively). A significant increase was noted in the GS group in both mean arterial pressure (MAP) and heart rate (HR) at 1 minute post-intubation (P < 0.05), although statistical differences became non-significant by 2 minutes post-intubation. Significant decreases in MAP were observed in the AWS group when compared to the MAC group at 3 minutes post-intubation, remaining statistically significant for the duration of the study (P <0.05).Conclusions Although intubation times in the AWS and GS groups were prolonged compared to the MAC group, our study suggests that the AWS may be preferable to the GS and MAC when attenuation of the hemodynamic stress response to endotracheal intubation is desired.

## INTRODUCTION

Hemodynamic responses to laryngoscopy and tracheal intubation are concerning, as adverse cardiovascular events may develop in patients with and without cardiovascular disease.[1,2] Tracheal intubation approaches that minimize oropharyngolaryngeal stimulation might attenuate this stress response. Two novel intubating devices include the Airway Scope® (AWS) (Pentax Corporation, Tokyo, Japan) and the Glidescope® (GS) (Verathon, Bothell, WA, USA). These video laryngoscopes do not require alignment of the oral, pharyngeal, and laryngeal axes for visualization of the glottis and endotracheal intubation, potentially attenuating the pressor response.

The AWS is used in conjunction with a disposable blade (Pblade, Pentax Corporation, Tokyo, Japan), which is anatomically designed to conform to the shape of the mouth and pharynx, and to be passed over the dorsum of the tongue.[3] Reduced neck movement is required when the AWS scope is used for tracheal intubation.[4,5] Because less lifting force, displacement of the tongue and other soft tissues, and cervical neck movement is needed, the AWS may be considered less invasive than the conventional Macintosh laryngoscope (MAC). The GS reduces the upward lifting forces needed to clearly expose the glottis because of its unique blade with a $60^{o}$ curvature that functions independent of the line of sight;[6,7] additionally, it requires less cervical neck movement for intubation,[5,7] making the GS also potentially less stimulating than the MAC.

Previously, Xue et al. compared hemodynamic responses to tracheal intubation with the GS to the MAC, finding that intubation time was longer with the GS, although no significant differences were found in hemodynamic values at any time point during their study.[8] In comparing the AWS to the MAC, Suzuki et al. found no significant differences in intubation time, systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) between groups.[9] More recently, Nishikawa et al. found that though there was no significant difference in intubation time between AWS and MAC, the AWS offered a degree of hemodynamic attenuation, as significant differences between groups were found in SBP immediately after tracheal intubation, 1 minute post-intubation, and 3 minutes post-intubation, and in HR immediately after intubation.[10] To date, no side-by-side studies investigating the pressor response to intubation using AWS, GS, and MAC have been published.

We hypothesized that both the AWS and GS would be able to attenuate the hemodynamic response to tracheal intubation, compared to direct laryngoscopy using the MAC blade; however, we theorized that the GS may be more stimulating to the anterior larynx than the AWS, secondary to the GS blade's acute $60^{o}$ angle. In the following randomized prospective study, we compared the hemodynamic stress response to endotracheal intubation using the AWS, GS, and MAC in normotensive adult patients receiving general anesthesia.

## METHODS

60 patients were enrolled in this study. Inclusion criteria included: aged 18 through 64, American Society of Anesthesiologists (ASA) physical status I or II, scheduled for elective non-cardiac surgery under general anesthesia requiring tracheal intubation, with a baseline blood pressure less than 145 mmHg systolic and 90 mmHg diastolic at the time anesthesia consent was obtained. Patients were excluded from the study if they had a history of hypertension, hypotension, cardiovascular disease, pulmonary disease, cervical spine disease, gastroesophageal reflux, or difficult intubation. Body mass index, Mallampati score, and thyromental distance were recorded at the time of anesthesia consent.

Patients fasted for 8 hours prior to arriving in the operating room, and were randomly assigned to one of three intubation groups: AWS (n=20), GS (n=20), or MAC (n=20). Midazolam 2 mg IV was administered for premedication 5 minutes prior to entering the operating room. Standard ASA monitors were attached, and the patient was preoxygenated for 5 minutes using 100% oxygen through a facemask. Subsequently, the patient was induced with lidocaine 1 mg/kg, propofol 2 mg/kg, and fentanyl 2 mcg/kg. After confirmation of ventilability, rocuronium 0.6 mg/kg was administered for muscle relaxation, and inspired sevoflurane was set to 1%.

After the nerve stimulator confirmed absence of twitches, the anesthesiologist performed laryngoscopy using the assigned intubation device; the trachea was intubated, using an endotracheal tube with an internal diameter of 7.0 mm for female patients, and 8.0 mm for male patients. The cuff of the tracheal tube was inflated with air immediately after endotracheal intubation. The duration for intubation was recorded as the time the anesthesia provider picked up the laryngoscope to the time of end-tidal $CO_2$ confirmation. End-tidal sevoflurane was recorded at the time of intubation. General anesthesia was maintained with sevoflurane 2% in 100% oxygen. The patients' lungs were ventilated with a tidal volume of 10 ml/kg and a respiratory rate of 10 to 12 to maintain end-tidal $CO_2$ at 35 mmHg. SBP, DBP, and HR were recorded at baseline, 1 minute after induction, at intubation, and at every minute for five minutes after intubation. Mean arterial pressure (MAP) was calculated for all time points. All intubations were performed by a single anesthesiologist with 1 year of experience with the MAC and at least 20 times experience with the AWS and GS.

As a power analysis from a previous article revealed, a sample size of 20 patients per group was required to achieve a power of 80% and an  of 0.05 for detection of 20 beats per minute or 20 mm Hg differences in paired hemodynamic data.[11] Comparison of hemodynamic data to baseline within groups was made by paired Student's t test. To minimize discrepancies in baseline blood pressure and HR between groups, the percentage change in relation to baseline was calculated for MAP and HR for all data points, in order to compare the stress response to intubation between groups. Analysis between groups was made by unpaired Student's t test. Statistical calculations were performed using GraphPad Prism® (GraphPad Software, La Jolla, CA, USA). A $P < 0.05$ was considered statistically significant, and a $P < 0.01$ was considered highly statistically significant.

## RESULTS

Patient demographic data is presented in Table 1. None of the patients were excluded from analysis according to criteria previously mentioned. There were no significant differences in patient characteristics between groups. Tracheal intubation was successful on the first attempt in all 60 patients. None of the patients developed severe hypotension (SBP < 60 mmHg) or severe hypertension (SBP > 170 mmHg). Intubation time was highly significantly longer with the AWS group (47.8 ± 17.5 sec) and GS group (44.4 ± 12.5 sec) compared to the MAC group (30.3 ± 7.7 sec) ($P < 0.01$, $P < 0.01$, respectively); there was no significant difference in intubation time between AWS and

GS groups (P = 0.48).

### Figure 1

| Table 1 Demographic characteristics of patients enrolled in study | Macintosh | Airway Scope® | GlideScope® |
|---|---|---|---|
| N | 20 | 20 | 20 |
| Male : Female Ratio | 14 : 6 | 12 : 8 | 9 : 11 |
| Age (y) | 33.8 (14.8) | 32.2 (10.7) | 34.8 (12.8) |
| Body weight (kg) | 75.6 (15.5) | 77.0 (20.6) | 73.0 (16.5) |
| Body mass index (kg/m²) | 26.1 (4.8) | 28.6 (7.7) | 27.4 (5.9) |
| ASA 1 : ASA 2 ratio | 9 : 11 | 10 : 10 | 7 : 13 |
| Mallampati score 1 or 2 | 20 (100) | 18 (90) | 19 (95) |
| Thyromental distance (cm) | 6.6 (1.1) | 6.3 (1.0) | 6.7 (1.1) |
| Intubation time (sec) | 30.3 (7.7) | 47.8 (17.5)** | 44.4 (12.5)** |
| End-tidal sevoflurane at intubation (%) | 0.8 (0.4) | 0.7 (0.4) | 0.7 (0.2) |

Data are presented as mean (SD) or number (%).
*Significantly ($P < 0.05$) different compared to the Macintosh laryngoscope.
**Highly significantly ($P < 0.01$) different compared to the Macintosh laryngoscope.

After anesthetic induction, SBP, DBP, and MAP were significantly decreased in the AWS group compared to baseline values, while HR significantly increased after induction compared to baseline (Table 2). In the GS group, significant decreases in SBP, DBP, and MAP were observed after induction compared to baseline values, although an isolated significant increase in DBP and MAP was seen at 1 minute post-intubation; by 2 minutes post-intubation, values had fallen back below baseline (Table 2). HR was significantly increased compared to baseline in the GS group by 1 minute post-intubation, and continued to be increased for the duration of the study (Table 2). In the MAC group, significant decreases in SBP, DBP, and MAP were documented after induction compared to baseline values, while no significant changes were noted in HR compared to baseline (Table2).

### Figure 2

Table 2 Systolic blood pressure (SBP) diastolic blood pressure (DBP) mean arterial pressure (MAP) and heart rate (HR) associated with endotracheal intubation

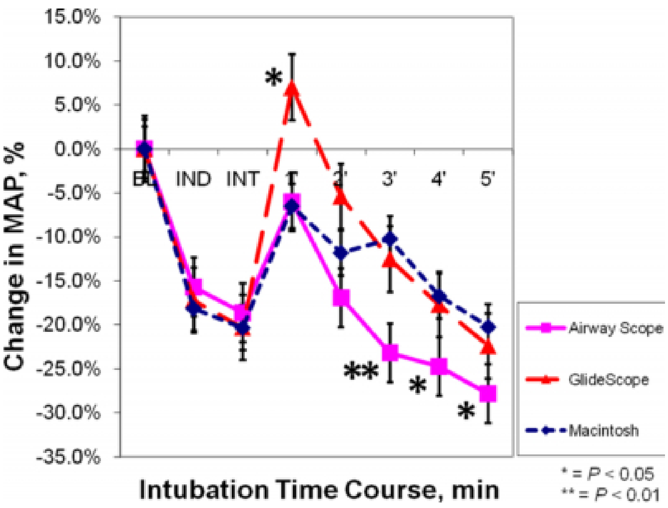
| | Groups | Baseline | Post-induction | At-intubation | Post-intubation 1 minute | 2 minutes | 3 minutes | 4 minutes | 5 minutes |
|---|---|---|---|---|---|---|---|---|---|
| SBP (mmHg) | AWS | 133.2 ± 12.8 | 112.7 ± 17.0** | 106.9 ± 12.5** | 124.2 ± 16.4* | 112.4 ± 14.9** | 105.3 ± 12.1** | 104.2 ± 12.7** | 100.0 ± 10.8** |
| | GS | 129.0 ± 16.5 | 105.9 ± 17.2** | 100.9 ± 15.7** | 129.3 ± 17.6 | 120.0 ± 19.8 | 112.6 ± 20.3** | 105.6 ± 18.5** | 100.2 ± 15.9** |
| | MAC | 128.6 ± 12.8 | 107.0 ± 17.6** | 100.2 ± 16.7** | 116.2 ± 20.8** | 110.4 ± 18.1** | 111.7 ± 19.3** | 106.8 ± 15.11** | 103.9 ± 13.8** |
| DBP (mmHg) | AWS | 81.6 ± 6.7 | 68.4 ± 10.6** | 66.6 ± 10.5** | 76.8 ± 12.6 | 67.2 ± 17.2** | 61.1 ± 11.1** | 59.6 ± 11.7** | 56.9 ± 11.8** |
| | GS | 73.6 ± 10.2 | 59.8 ± 13.5** | 57.9 ± 11.4** | 80.7 ± 17.0* | 68.6 ± 12.6 | 63.5 ± 18.0** | 59.6 ± 15.8** | 55.4 ± 11.0** |
| | MAC | 73.2 ± 9.0 | 59.3 ± 14.8** | 59.0 ± 14.5** | 70.2 ± 17.4 | 65.5 ± 15.1* | 66.9 ± 14.9 | 60.8 ± 14.0** | 57.6 ± 11.6** |
| MAP (mmHg) | AWS | 98.8 ± 7.9 | 83.2 ± 12.2** | 80.0 ± 10.3** | 92.6 ± 12.3* | 82.3 ± 15.7** | 75.8 ± 11.0** | 74.4 ± 11.3** | 71.3 ± 10.7** |
| | GS | 90.8 ± 11.2 | 75.2 ± 15.6** | 72.2 ± 11.7** | 96.9 ± 16.6* | 85.7 ± 14.5 | 78.9 ± 18.1** | 74.9 ± 16.2** | 70.9 ± 11.9** |
| | MAC | 91.7 ± 8.7 | 75.1 ± 14.8** | 72.7 ± 13.6** | 85.5 ± 18.0 | 80.5 ± 13.8** | 81.8 ± 15.4* | 76.1 ± 12.3** | 73.0 ± 11.0** |
| HR (bpm) | AWS | 83.9 ± 16.1 | 89.9 ± 15.5* | 91.9 ± 16.8** | 97.8 ± 16.5** | 97.4 ± 17.1** | 97.1 ± 16.0** | 95.2 ± 16.9** | 93.8 ± 17.1** |
| | GS | 80.0 ± 19.4 | 81.4 ± 15.1 | 83.6 ± 19.0 | 99.3 ± 13.9** | 96.6 ± 15.9** | 94.2 ± 15.7** | 91.5 ± 16.3** | 90.3 ± 16.6* |
| | MAC | 78.9 ± 5.4 | 76.3 ± 6.5 | 77.4 ± 5.8 | 82.3 ± 6.2 | 86.4 ± 7.0 | 85.9 ± 18.7 | 85.6 ± 16.0 | 81.9 ± 14.0 |

Data are presented as mean ± SD.
AWS, Airway Scope®; GS, Glidescope®; MAC, Macintosh.
*Significantly ($P < 0.05$) different compared to baseline values.
**Highly significantly ($P < 0.01$) different compared to baseline values.

When hemodynamic comparisons were made between the AWS and GS groups to the MAC group, a significant percentage increase was noted in the GS group in both MAP and HR at 1 minute post-intubation, although statistical differences became non-significant by 2 minutes post-intubation (Figure 1,2). Significant percentage decreases in MAP were observed in the AWS group when compared to the MAC group after 3 minutes post-intubation, continuing for the duration of the study (Figure 1).

### Figure 3

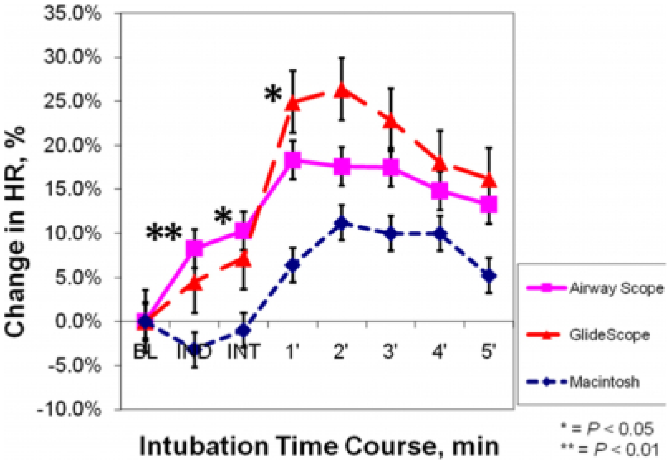
Figure 1 The percentage change in mean arterial pressure (MAP) compared to baseline associated with endotracheal intubation in the three groups. Data values are presented as mean Â± standard error. * < 0.05 compared to Macintosh group. ** < 0.01 compared to Macintosh group. BL, baseline; IND, 1 minute after induction; INT, at intubation; 1Â’, 1 minute post-tracheal intubation; 2Â’, 2 minutes post-tracheal intubation; 3Â’, 3 minutes post-tracheal intubation; 4Â’, 4 minutes post-tracheal intubation; 5Â’, 5 minutes post-tracheal intubation.




The HR percentage change was significantly elevated after induction in the AWS group compared to the MAC group, although differences became non-significant by 1 minute post-intubation (Figure 2).

## Figure 4

Figure 2 The percentage change in heart rate (HR) compared to baseline associated with endotracheal intubation in the three groups. Data values are presented as mean Â± standard error. * < 0.05 compared to Macintosh group. ** < 0.01 compared to Macintosh group. BL, baseline; IND, 1 minute after induction; INT, at intubation; 1Â’, 1 minute post-tracheal intubation; 2Â’, 2 minutes post-tracheal intubation; 3Â’, 3 minutes post-tracheal intubation; 4Â’, 4 minutes post-tracheal intubation; 5Â’, 5 minutes post-tracheal intubation.




## DISCUSSION

Our study found that though intubation time was significantly longer with the AWS and GS compared to the MAC, the AWS may best attenuate the hemodynamic stress response; significant percentage decreases in MAP from 3 to 5 minutes post-intubation were observed in the AWS group compared to the MAC group. The GS may be the most invasive intubating device, considering the significant percentage increase in MAP and HR at 1 minute post-intubation compared to the MAC. However, this statistical difference occurred only at a single time point, and differences became non-significant by 2 minutes post-intubation.

The two main causes of hemodynamic responses to tracheal intubation are stimuli to oropharyngeal structures produced by laryngoscopy, and stimuli to the larynx and trachea secondary to tube insertion; however, the pressor response can also be influenced by prolonged intubation time.[12] A potential reason for an increased time to intubation with the GS may stem from difficulty advancing the endotracheal tube through the glottis. Because of the blade’s anterior curvature, the tube tip may become snagged on the anterior wall of the upper trachea, requiring slight rotation of the tube, withdrawal of the GS blade, or flexion of the neck to advance the tube; these maneuvers can all increase stimuli to the pharynx and larynx.[13]

Likewise, intubation time with the AWS may be prolonged secondary to the AWS’s wide Pblade, which incorporates a groove to attach the tracheal tube, and measures 49 mm across; insertion of this blade may also be associated with increased stimulation to the base of the tongue and pharyngeal structures. Although the AWS is designed so that the tip of the tracheal tube can be continuously confirmed during the entire course of the tracheal intubation, and the attached tracheal tube is designed to advance towards the target mark on the liquid crystal device monitor display,[4] we found that advancement of the tracheal tube through the glottis was sometimes delayed secondary to impingement of the tube on the arytenoid cartilage, requiring subtle maneuvers of the AWS to free the path of the tube towards the trachea.

A possible reason for why the AWS may better attenuate the hemodynamic stress response compared to the GS and MAC is that passage of the tube with the AWS follows a posterior route, in which the blade is inserted along the palate and posterior pharyngeal wall to facilitate passage behind the epiglottis, which may be less stimulating to the pharyngeal structures than the GS and MAC’s anterior approach, in which the blade tip glides along the surface of the tongue towards the tongue base.[14]

There are several limitations of our study. First, our study population appeared to be hypovolemic, based on hemodynamic responses after induction (decreased SBP, DBP, MAP, and increased HR) (Table 2). This may have been secondary to a conservative fasting period (Nil per os for 8 hours). One might assume that the results observed in this study may not be generalized to a euvolemic population. However, baseline values were not significantly different between groups, so one could assume that our standardized induction affected all groups equally. In order to minimize discrepancies between groups, we elected to compare MAP and HR values as percentage change in relation to baseline.

A second study limitation was the fact that hypertensive patients were not evaluated in this study; these patients may respond differently to pharyngeal and laryngeal stimulation.[15] Thirdly, all intubations were performed by a single anesthesiologist with variable experience with these airway devices; this could have biased the results, although the success rates for all devices were the same, suggesting that performance with all three devices was comparable.

Fourthly, although patients were randomly assigned to groups, double-blinding to observe hemodynamic changes could not be accomplished in this study. Fifthly, our study results are specific for our anesthetic regimen, and may not apply to other techniques, such as a narcotic-based approach.

In conclusion, intubation times in the AWS and GS groups were prolonged, compared to the MAC group. Despite this fact, no significant percentage increases and several significant percentage decreases were recorded in the AWS group compared to the MAC group after intubation, suggesting that the AWS may be preferable to the GS and MAC when attenuation of the hemodynamic stress response to endotracheal intubation is desired.

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